n o p q w v u

a a. Fontenelle.
b b. Plato.
c c. Archimedes.
d d. Mare Imbrium.
e e. Aristarchus.
f f. Copernicus.
n n. Kepler.
o o. Mare Humorum.
p p. Mare Nubium.
q q. Tycho.
u u. Petavius.
v v. Theophilus.
w w. Maurolycus.
r r. Mare Serenitatis.
s s. Posidonius.
s s'. Atlas.
t t. Mare Crisium.

THE COMMON SIGHTS IN THE HEAVENS,

AND HOW TO SEE AND KNOW THEM.

BY

CAPTAIN A. W. DRAYSON, R.A.

8
1454

LONDON:
CHAPMAN AND HALL, 193 PICCADILLY.
1862.

QB46
D76

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET.

PREFACE.

In the following pages will be found a simple description of the various sights which can be viewed in the heavens during the day and night.

When possible the pencil has been used to aid the description given by the pen.

This book merely pretends to give an account of those objects which may be seen with a common telescope, or even by the unaided eye. All scientific terms have been as much avoided as possible; and although in some instances diagrams which look suspicious, and appear to tend towards geometry, have been inserted, still a moment's examination will, we trust, prove their innocence, and show that

they are quite intelligible even to the most unmathematical mind.

Under these circumstances it is hoped that all readers may be able to understand and to feel an interest in those subjects which are here lightly touched upon.

COMMON SIGHTS IN THE HEAVENS.

CHAPTER I.

Every person who possesses sight is provided with the means of perceiving a whole host of interesting and beautiful celestial objects. If the same individual is disposed to spare a few minutes during the many clear nights in the year, to the examination of the various heavenly bodies, he will shortly become possessed of such an amount of information that a new sphere of investigation will be introduced to him. If, in addition to these natural gifts, he is fortunate enough to be provided with a common telescope, or possesses about three pounds of spare cash, so as to provide himself

with one, he is then armed with sufficient means to enable him to examine closely the chief characteristics of those vast floating bodies which, night after night, apparently move around this world, and reveal their wonders to the gaze of the inquirer.

It is a common, but at the same time a very mistaken idea, that all which appertains to the celestial bodies, their movements, condition, and positions at various times, is of such a complicated and puzzling nature, that very few minds are capable of comprehending even the elements of the science which treats of this subject. Hence very few individuals are disposed, or can afford, to devote several years of exhausting study to acquire a knowledge of mathematics, geometry, Greek, and the many other sciences which they believe are requisite to be known, before they can comprehend even the common interesting portion of that vast page, which extends from the horizon to the point above us in the heavens.

To comprehend the science of astronomy (as it

is taught) requires of course a considerable preparation; but to be able to enjoy the fruit of this science requires little more than eyes, a telescope, and a few minutes' attention.

There are several other subjects which may be said to really occupy nearly the same position as that assumed for astronomy. Walking, for instance, is a very healthy and useful occupation. If, however, no person was allowed to walk, or believed that he could not do so until he knew exactly what muscles, nerves, and joints he called into action,—could explain how the will, by a mysterious agency, acted upon the matter composing the body and legs, how much air was displaced by the motion of the body, &c.,—we might all become very scientific people; but probably should soon become imbecile, although we might possibly look with contempt upon the healthy countryman who walked ably, but who knew not the science of that which he was doing.

Thus to be able to understand the peculiar beauties of the most interesting objects in the

heavens, is within the grasp of certainly ninety-nine out of every hundred individuals, although they may be entirely unacquainted with science, but possess merely common observation.

There are in the heavens a variety of beautiful objects. During the day there is the glowing sun, whose heat and light are essential to the production and continuation of animal and vegetable life, whose rays gladden and enliven the earth, and whose daily advent calls forth an harmonious song of praise from a myriad feathered songsters.

With a calm, subdued light the crescent-shaped moon may also be seen in the day-time, perhaps half her illuminated surface being then turned towards the earth.

When the mighty orb of day has run his course, and has retired from that part of the heavens which appears arched above us, then thousands of less gorgeous objects timidly peep forth from their concealment, and, perceiving the earth in shadow, they hasten to display their pale, brilliant fires, until at last the

heavens appear studded with thousands upon thousands of sparkling lights, which, although smaller, are scarcely less bright than the mid-day sun.

The evening and the night are the periods when the heavens yield most abundantly a field for amusement, and it is then that the wonders revealed therein can be most calmly contemplated. The lover of nature, whose thoughts are given to the examination of terrestrial wonders only, is not able to roam during the darkness of night, and perceive those beauties for which he may be in search; neither can he, during the somewhat long periods of darkness in winter, find many of those interesting natural objects which abound in summer. Yet it is in these very seasons and times that the heavens offer us so fruitful a source of amusement, and reveal to our gaze so many subjects upon which we may employ our thoughts and researches.

Our interest in the celestial bodies is much increased when we know that many of these are worlds like that on which we live, and that

they differ apparently from it merely in some minor details, or in the presence or absence of certain conditions, which will be, or may have been, those of this globe in the coming ages of the future, or in the no less vast and mysterious epochs of the past.

To the most superficial observer, there appear to be merely three descriptions of bodies in the heavens, viz., the sun, the moon, and the stars. The latter appear to vary from each other in size and brightness as well as in colour; but unless some slight attention be directed to them, they seem to present very little variety.

Observation, however, has shown that the so-called stars must be divided into two classes: the first comprises those bodies which always maintain the same position with regard to each other, and which are at an immense distance from our world, and which shine by means of some property inherent in themselves. The second class consists of those so-called stars which move amongst the other stars, and which, it is found, are at certain calculable dis-

tances from our earth, and which only shine or appear bright because the sun shines upon them.

Those of the first class are called "*fixed stars*," those of the second "*planets*." *

It is found that all the planets move around the sun; that they all spin round, or *rotate*, as it is termed, and that they are all somewhat of the shape of an orange.

Many of the planets are attended by certain bodies termed satellites, which move around them just as the planets move round the sun; these attendants are called "*satellites*," "*moons*," or "*secondaries*;" our moon being a satellite or secondary to the earth.

The sun, the planets which move round him, and their satellites or moons, are termed the *solar system*, which is thus like one family; the sun the apparent father, or head, the various planets the children, whilst the satellites are the grandchildren.

The sun and full moon appear to us nearly of the same size, whilst the various planets

* From *planétes*, wanderers.

differ considerably in their visible dimensions. Appearances are proverbially deceitful, and the proverb holds good most effectually when applied to the celestial bodies. The proportional difference between the size of the sun and the moon, is about that which exists between the 'Great Eastern' steam-ship and a little boy's toy-boat; the similitude in their apparent size being due to the difference in distance from the earth between the two. We can easily comprehend the effect of distance in altering the apparent size of objects if we look through our window, where the pane of glass close to us looks larger than a church at a distance.

The various planets differ in their size, although not so much as the moon and the sun. Still there are some which would cause our earth to look a very insignificant object if the two were placed side by side, and examined from a distance.

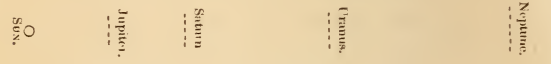
The accompanying table will show the relative diameter of the sun and the eight primary planets, of which the solar system consists.

		Miles.
Sun	about	888,646
Jupiter .	„	89,000
Saturn .	„	76,000
Neptune	„	37,500
Uranus .	„	35,000
Earth .	„	7,912
Venus .	„	7,800
Mars .	„	4,189
Mercury	„	3,140

There are, besides, a number of small planets which revolve round the sun, and are really primaries: these, however, are not considered to rank amongst the eight leading planets in the system; they are very small, and present peculiarities which distinguish them from the principal members, and they are, besides, scarcely visible unless with the aid of a telescope. Five of the principal planets, viz., Mercury, Venus, Mars, Jupiter, and Saturn, can be plainly seen with the unaided eye. Uranus is also visible, as a rather dim object; but, with the aid of a large telescope, reveals a circular and planetary form.

These planets all move round the sun, and at different distances; the relative position of each is shown below.

A different scale is now used to show the distant planets, Jupiter's distance being given.



THE SUN.

Solar Spots.

Vincent Brooks lith.

Changes in a Solar Spot passing across Sun's disc.

CHAPTER II.

THE SUN.

EVERY person must have observed that the sun is higher in the heavens at midday in summer than in winter, and that it remains longer above the horizon in summer than in winter. If the sun be observed during twelve months, it will be found that about the 22nd of December, at midday, it will be lower down than at any other time in the year; and about June the 21st it will be higher up than at any other time.

If we could make two marks in the sky to show the two places where the sun reached at midday, on the 21st of June and 21st of December, we should find that about the 20th of March and the 22nd of September the sun was just midway between these marks.

If we measured with an instrument the daily

height of the sun, which is always greatest at midday, we should find that, early in January, the sun increased its height very slowly from day to day, and that during a week it varied a very little more than its own diameter.

Then it would go on increasing more quickly until March the 20th, when, during one day, there would be an increase in height equal to nearly the sun's diameter.

After this date there would be a gradual decrease in the *rate* until June, although still a daily increase in height.

When, then, we have passed the shortest day, we do not observe any very great difference in the length of sunlight during a few days; then there is a slow and steady increase, the difference being greatest during the month of March, when the days increase rapidly in length; after this date there is still a gradual increase, but the rate is not so great. In fact, during the thirty days in March, as great a change occurs in the sun's midday height as there is during the ten days of December, the thirty-

one days of January, and the eleven days of February. So that in thirty days of March there is as great a change as during the fifty-two days from the 21st of December on to the 11th of February.

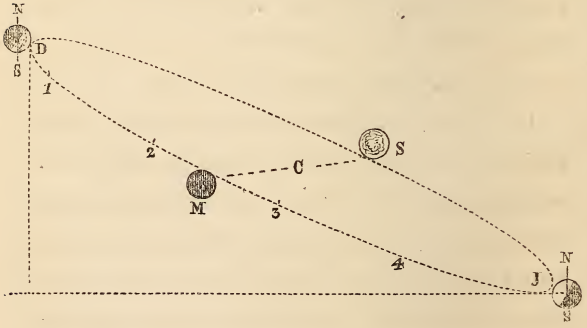
After the 21st of June the daily greatest height of the sun begins to decrease, and in a manner exactly similar to that in which it increased, viz., slowly at first, and quickest when about midway in its course of descent. Thus, in September, there is a very rapid decrease, just as in March there was an increase in the daily height of the sun; then the *rate* of decrease becomes less, until the 21st of December.

These changes occur year after year with regularity, no difference being observed unless the most accurate instruments are employed.

The *cause* of the sun's variation in height is the movement of the earth round the sun, and in a sort of up-and-down manner. Thus, if we call the northern half of the world the *upper* half, and the southern half the *lower*, then we

may say that on the 21st of December we are above the sun considerably; from this date to the 21st of June the earth moves downwards, and round a circle, in the centre of which is the sun. On the 21st of March the earth is level with the sun. From the 21st June to the 21st December the earth moves upwards, and is again level with the sun on the 21st of September.

By means of a common hoop, we may see why the sun rises and falls each day, more quickly, in March and September, than at other times of the year.



Thus, suppose D M J S a hoop resting on a

table J, and propped up at D above the table, and suppose C the centre of this hoop. If we moved anything from D to 1, it would not have moved *downwards* very much, because this part of the hoop is nearly level. As this same thing moved from 1 to 2, it would have moved downwards much more, although the distances from D to 1 and from 1 to 2 were equal. From 2 to 3 there would be a more rapid fall, whilst from 3 to 4 a more gradual descent. At M the body would be level with C, at D above it, and at J below it.

This is just the course that the earth pursues round the sun; D being the December, M the March, J the June, and S the September position; C being the position of the sun.

The earth is distant from the sun about ninety-five million miles, a distance which would occupy an express train about two hundred years to travel. In consequence of the earth moving round the sun, our annual journey amounts to nearly six hundred million miles: thus each day of our lives we travel more than a million and

a half miles through space, or a distance equal to about sixty times round the earth.

If we stand at some railway crossing and see an express train rush past, the iron horse snorting and whistling, the dust flying, the wind almost knocking us down, and then observe the passengers reclining calmly in the carriages, or talking to each other, we cannot well fail to ponder upon the singular anomaly thus presented to us. There is a mass of carriages which appears to be jolting and crashing onwards to destruction, at the rate of nearly fifty miles an hour, and yet the most timid of the occupants of the carriage appears to suffer no alarm. This is certainly a grand sight, although we are familiarized to it, and therefore are but slightly impressed with the indication of power thus manifested. If, however, an express train dashing past us is at all a source of admiration, how much more impressed we should be, were we able to observe from space, a vast world which would come rushing and spinning past us, with a velocity of sixty-eight thousand miles an hour!

Every human being, therefore, is a great traveller, although he may repose in his arm-chair from day to day. The cannon-ball that moves too quickly to be seen is merely a slow coach compared to the world upon which we live, and our world is slow when compared to the little planet Mercury, whose rate is nearly double that of the earth.

At noon the sun will be south of all localities in England. The sun appears to move round the earth in twenty-four hours; therefore, in six hours it moves round one fourth of the earth, and consequently will be found near the west at six o'clock in the evening, and near the east at six o'clock in the morning. If we know the time, therefore, and can see the sun, we can always tell where the cardinal points of the compass are situated; for as the sun is south at noon, and near the east at 6 A.M., it would be nearly south-east at 9 A.M., between south-east and south at half-past 10 A.M., and so on.

If the time of sunrise be added to that of

sunset, the sum of the two will nearly always amount to twelve. Thus, if the sun rise at 8 A.M., it will set about 4 P.M.; and if it rise at 5 A.M., it will set about 7 P.M.: thus, if we know the time of sunrise we may obtain that of sunset, or *vice versâ*, because the sum of the two should amount to twelve.

We will first call attention to those interesting facts which may be seen by the unaided eye, before we refer to those which require some artificial means to enable a person to see them distinctly.

Among the most singular phenomena connected with the sun, the midnight sun to an inhabitant from the central portions of the globe must appear at first very curious. In England we are accustomed to have twilight from about the 21st of May until the 21st of July, during which period the nights are nearly as light as many of our November days. This, however, is very different from seeing the sun above the horizon at midnight, and shining as brightly as he does in England towards the afternoon of

an autumn day. To view the midnight sun we must travel to within about twenty-three and a half degrees from the north or south poles—that is, we must travel to about sixty-six and a half degrees of north or south latitude. In Spitzbergen, the north of Iceland, the north of Norway, in Baffin's Bay and Greenland, the midnight sun will be visible during June. The farther north that we go from England, the lighter will be the nights during the summer.

When we are at the central—*i. e.*, the equatorial—latitudes of the earth, we have the sun directly overhead during midday in March and September, and a very little way from the same point during midday in June and December.

The nights at the equator are dark as Erebus. If the moon does not shine, and if there be a few clouds to cause the stars to look dim, then an English winter's night is twilight compared to the summer night at the equator.

At sunset, also, the sun, instead of passing

obliquely below the horizon, descends perpendicularly — so that twilight has scarcely any existence at or near the equator.

In England, and in localities in the northern half of the world, it is customary to talk about turning a screw, or dealing at whist, &c., *with the sun*—that is, from left hand to right. When, however, we have crossed the equator, and have travelled some sixteen hundred miles on the other side, these directions become incorrect, for the sun there appears to rise from the right hand and to set on the left, and to pass at all times of the year from right to left, instead of from left to right.

Exactly the same change in right and left movement would occur if a weight were to be swung backwards and forwards between two people who were standing face to face. Each time the weight moved to the right of the one person it would move to the left of the other, and *vice versâ*.

This change in the apparent movement of the sun having been observed is a rather con-

vincing proof that the Phœnicians rounded the Cape of Good Hope as long ago as 400 B.C.—that is, upwards of two thousand two hundred and sixty years ago; for Herodotus states that there were some travellers who sailed down the Red Sea and returned by Gibraltar, and stated a thing which *he* could not believe, though others might—viz., that during their journey they observed the sun rise from their right hand and set upon their left.

This fact was not likely to be guessed at by sailors had they not seen it, especially in an age when it was thought unscientific and foolish to believe that the earth was spherical instead of a plane, and when scarcely a single traveller had crossed the equator, or even ventured within the tropics.

The sun sometimes, when rising or setting, appears of a blood-red colour, and of a very large size. If measured with an instrument at this period the sun is really not larger than at another time; it therefore follows that there must be some effect produced upon the eye,

which is not a real enlargement in the actual size of the sun, or in its measured size.

These considerations induced the earlier astronomers to believe that the large size was a delusion caused by the sun being compared with terrestrial objects when he was near the horizon, whilst when he was elevated in the heavens there were no objects with which to compare him.

A very little consideration would soon have shown that this could not be the true explanation of the phenomenon; for in consequence of the sun setting every evening, and rising every morning, the same effects ought *always* to be observed, whereas it is only two or three times each year that this singular effect is seen.

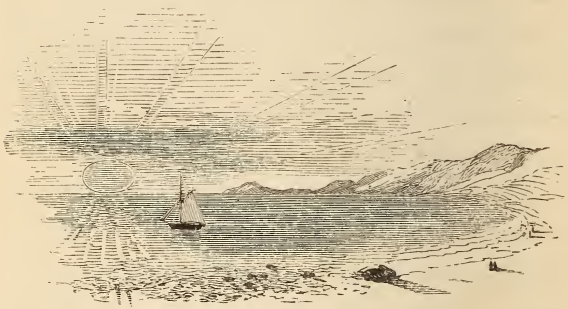
From another fact, also, the inefficiency of this explanation would have been manifest—viz., that the large red sun is observed very frequently at sea, when the ocean is calm as a lake, and no terrestrial or other objects are within a hundred miles.

It is far more probable that the enlarged

appearance is due to a peculiar state of the atmosphere, a condition probably analogous to that which enables us at times to perceive quite distinctly distant objects, which then appear larger than usual. When this condition exists, the "weather-wise" prophecy a change of weather, and usually consider that rain will shortly fall. A register of the weather before and after this singular appearance of the sun might enable us to collect some useful facts.

When the sun is just close to the horizon he appears usually to be egg-shaped, instead of circular, his longest portion being parallel to the horizon. This effect is due to what is called *refraction*. Refraction is the term used to indicate the bending of the rays of light as they pass through the atmosphere or through water. The nearer any celestial body may be to the horizon the more would a ray of light from it become bent; and thus, as the lower part of the sun is nearer the horizon than the upper part, then the light from the lower part becomes the more bent, whereas no difference

is produced upon the horizontal width of the sun. The following sketch shows the appearance referred to. The sun is there shown just resting on the horizon, and its shape altered from a circle to an oval. According to the



state of the atmosphere this apparent distortion increases or diminishes, but it is usually very considerable. The most singular fact connected with it is that when just visible above the horizon, as shown in the sketch, the sun is actually below the horizon, and is brought into view by refraction.

A very rare and singular appearance is that called *parhelion*—near the sun. Sometimes

two, three, or more suns are visible in the heavens at the same time. In high latitudes this appearance is not uncommon, but in lower regions it is rarely witnessed. Aristotle mentions an instance of two mock suns having been seen the whole day on the Bosphorus; and Pliny tells of a triple sun having been seen by him during the reign of Claudius. Hevelius, an astronomer of celebrity at Dantzic, relates that seven mock suns were once noticed by him. These mock suns usually appear on each side of the real sun, or above and below it, and thus rest upon the circumference of a halo which surrounds the sun.

When examined by the unaided eye the sun appears a brilliant luminous body, without a speck. If, however, a telescope be directed to him, and if the eye be protected by means of a piece of dark glass, the sun then presents a sort of mottled surface, which is by no means perfectly clear, but which appears at all times to be covered by a series of dark and irregular lines; and at uncertain periods black spots of

large size appear upon his surface. The smaller streaks visible on the sun do not seem to change in any way, nor do they offer any peculiarities which can serve as guides to their constitution. The large spots, however, are usually undergoing changes, and these present phenomena which are well suited for the foundation of speculation.

The spots upon the sun serve to make us acquainted with one or two facts of interest. They show us that the sun turns upon its axis just as does the earth and the principal planets in the system. They indicate where the equator of the sun is situated, and they enable us to find the length of time occupied during his rotation.

It not unfrequently happens that a person possessing good sight can see with the naked eye some one or two spots upon the sun, provided that a piece of coloured glass be used as a means to subdue his brilliancy. When taking altitudes with Hadley's sextant, and without a telescope, I have usually distinguished a spot

upon the sun; the combined effect of the red and green glasses being the most favourable for such an examination, as the sun then appears to be a pale yellow, whilst the spot is black.

It has been considered remarkable that some of the ancients should have known of the existence of spots on the sun, before the telescope was invented; but if any person carefully examine the sun's surface each day by the aid of pieces of yellow and red, or red and green glass, or even look at the sun's reflection in a pail of water, it will appear singular how any observer could have omitted to notice the spots, as they can be easily seen with the naked eye. During a London fog, when the sun is only just visible, I have seen the spots very distinctly. To watch the changes which take place, and to see clearly the peculiarities which appertain to the spots, a telescope with a moderately powerful magnifying power should be used, and a dark eye-piece fitted on to the eye end of the telescope. To observe any celestial body thoroughly, the telescope should be arranged

upon some kind of stand, and protected from the wind. When even a telescope of average power is thus protected, the changes in the spots on the sun may be observed, and a register kept of the maximum and minimum quantity, from which some valuable facts might be adduced.

To a person unacquainted with the simplicity of some astronomical problems, it may appear a very difficult matter to tell which is the sun's pole star, and how his equator is arranged relatively to that of the earth. To approximate very closely to both these data is, however, a very easy matter, which is accomplished as follows:—

Suppose that upon a common globe we arrange several black spots, and then stand at a distance and watch these spots when the globe is made to turn round. If we walked around the globe, we could soon tell in which direction its axis pointed, for when we found the spots traced straight lines, we should then know that the axis was at right angles to

these lines, and we should consequently know in which direction it pointed. So is it with the spots on the sun, which are found to trace straight lines during June and December, and curved lines at all other times of the year. Thus, if from day to day we were to mark on a circle the position of the spots, we should find that a line joining these various positions would appear, as shown below, at the various periods indicated.

December.

March.

June.

September.

During June and December the spots trace straight lines, which make an angle of about seven degrees with a horizontal line on the earth at midday. During March and September the spots trace curved lines. Thus from the earth we can look upon the north pole of the sun during September, and upon the south pole of the sun during March.

If any particular spot be observed, it is found to move from the left across to the right of the sun. The motion is exactly that which would occur if the spots were fixed to a rotatory ball, and it is therefore only reasonable to conclude that the sun turns upon an axis.

If any one spot be watched, it is found to return to the same position in a period a little over twenty-seven days. Making the proper allowance for the movement of the earth during that time, it is found that the sun turns round in about twenty-five days and a half. The probable object of this rotation will be considered at a future page.

A spot if examined with a large telescope is observed to undergo changes in size and shape, but rarely, if ever, to alter its position. When the spot first appears upon the left side of the sun, there is usually a dark and a light portion, as though some reflected light were cast upon the side of a hollow cylinder. When the spot is seen at the central portions of the sun, then it is all black, but usually with a

lighter fringe. When on the right side of the sun, it is lighted in the same manner, only upon the opposite side to that upon which it was lighted when it became visible upon the left side. The sketches on Plate 2 will show the apparent changes which usually take place in a spot as it is carried across the face of the sun.

Many speculations have been made as to the nature of the solar spots, but up to the present time very little is known about them. It may be many years before we ascertain for certain whether they produce any effect upon our climate, or upon the earth at all; and it is probable that until we have some other means than mere conjecture for arriving at truths connected with remote objects, the spots on the sun will still continue to be mysteries.

From observations carried on within the last thirty years, there appears some probability that the spots are in the greatest profusion at intervals of about ten years, whilst in the intermediate periods the least number have been observed. In the year 1828 there were, ac-

cording to the observations of M. Schwabe, 225 groups of spots observed: in 1833, only 33 groups. In the year 1837 there were 333 groups seen; whilst six years afterwards, viz., in 1843, there were only 34. Again in 1848 there were 330 groups seen. Thus at intervals of nearly ten years the maximum number of spots have been observed.

It is a little singular, and it may be considered rather beyond the range of chance, that the greatest magnetic changes on earth are found to correspond with the periods when the maximum and minimum number of spots are observed on the sun. Thus it is highly probable that there is a connection between these two phenomena which may either be both the effects of some other great natural cause, or, as is more probable, that terrestrial magnetism is connected with the sun's condition.

The most popularly received idea about the sun's spots is, that they are openings in a luminous atmosphere by which he is surrounded, and that consequently it is the dark

body of the sun that is seen, in the shape of a spot. There is a great difficulty about this hypothesis, inasmuch as it requires us to assume some curious laws to be acting in connection with the sun's atmosphere. On earth it is impossible to produce a permanent hole in water, and it is equally as difficult to form a hole in the atmosphere. Unless, therefore, we assume that the sun's atmosphere is solid, it is doubtful whether a permanent hole could be produced in it. And thus we have to *assume an atmosphere of a particular nature* before we can imagine any holes to be made in it.

During the evenings of March and April, and before sunrise in October, there appears sometimes a faint luminous cone of light near the sun, which in appearance is not unlike the tail of a comet. In these latitudes this phenomenon, called the *zodiacal light*, is not so often seen as it is in equatorial regions. It has been remarked, that when the sun is free from spots the zodiacal light is rarely seen, but when the opposite condition prevails, then the

light is frequently observed. The colour is usually of a rose-pink, and it varies in intensity according to the state of the atmosphere.

It is impossible to avoid feeling grateful to the great Ruler of the universe, when we realize the vast enlightenment which has taken place in the human mind since the earliest ages of man. We can scarcely bring before us any example which so completely exemplifies this fact as that connected with the present knowledge of the movements of the heavenly bodies.

In the olden times, centuries before England was anything greater than the residence of barbarians, the movements of the celestial bodies had occupied the attention of the Eastern sages; but in too many instances the slight knowledge which they did possess, was treasured merely because it enabled the possessors to wield an influence over the ignorant and bigoted.

An eclipse of the sun, which can now be predicted years in advance, and within a minute

of the time of its occurrence, was in the olden time a cause of fear and dread, and was made use of as an excuse for sacrificing victims to superstitious bigotry, or for the purpose of extorting obedience from an alarmed and ignorant public.

Those who have studied the history of even modern progress, and have seen how in a comparatively enlightened age innovations have been scouted, and great truths rejected and abused for years, or until the facts became too powerful to be denied, can imagine what must have been the fury and astonishment of those antiquated *savants* who had long taught astronomy and astrology, when it was first announced that a solar eclipse was caused by the intervention of the dark body of the moon. This assertion was so utterly at variance with that which was in the earliest ages called real orthodox science, that it merely excited the anger or ridicule of the hearers.

There appears to be tolerably good evidence to show, that the Chaldeans were able to foretell

with some certainty both eclipses of the moon and of the sun; yet when Anaxagoras the Greek announced that it was the moon which caused a solar eclipse, his assertion brought upon him the censure of his countrymen, and he was banished as an infidel.

To most modern minds the explanation of an eclipse appears so simple, that we wonder how any other cause could for a moment have been accepted. Yet when the mind has from childhood been taught that certain effects are due to such and such causes, it is very difficult to uproot this teaching, though to the unprejudiced it may appear absurd and unnatural.

It must have indeed been a hard trial for the advanced men of the early ages, who, having patiently thought and carefully observed, at length wished to explain the cause of eclipses. The hearers were so different from a modern audience, that we can only imagine their state if we have witnessed the unreasonable proceedings of some half-savages, upon whom logic, argument, demonstration, or facts would

produce no more effect than the same weapons upon a herd of swine. Yet what must have been the inward feeling of those few leading minds who had read aright the page of nature? Observing in some solitary tower, the astronomer must have felt himself almost in another world as he found his reasoning true, and his calculations connected with the period of an eclipse verified by facts. Still, as in all cases, a price must be paid for the possession of knowledge; and this solitary student of the heavens must at times have felt lonely, and must have thirsted for a few kindred and expanded minds with which to exchange ideas; for the more elevated become our thoughts the more do we contract the circle of our boon companions.

An eclipse of the sun is a sufficiently rare phenomenon to excite universal attention. To astronomers an eclipse becomes interesting in consequence of its being the means whereby they may correct any errors which exist in the calculated positions of the sun and moon; for

although the principal movements of these two bodies are now well known, still there are some minor changes which occur, and which from time to time require that corrections should be made.

The first object observed in a solar eclipse is that the sun has lost its circular form, and appears to have a chip taken out of his western side. This chip becomes larger and larger, and as it does so the sunlight becomes dim, and the landscape is seen by means of an unnatural pale-yellow light. According as the eclipse is partial or total, and according as the moon passes across the upper or lower portion of the sun, so will the commencement of the eclipse produce a variety of appearances. When the eclipse is at its maximum the sun may be entirely obscured, or may appear as a ring of light, according as the eclipse occurs when the moon is at the least or greatest distance from the earth.

It is when the sun is almost entirely obscured that some singular appearances have been ob-

served at the extremities of the moon. The first of these consists of a number of protuberances, or prominences, which become visible on various parts of the extremities of the moon. These are sometimes of a lake-red colour, sometimes bright red, and at other times nearly white. The sketch, Plate 3, shows the general appearance of these protuberances.

Several theories have been invented to account for the observed facts, but, like the spots, all is as yet mere speculation. Some observers have supposed that the red flames have been seen just where there was a large spot on the sun; but it as often happens that where no spots exist there the flames are visible. From careful observations which have been made since 1842, it is probable that the appearance results from some condition existing on the sun, and is not due to anything on the surface of the moon: thus probably they are merely material objects, perhaps similar to clouds in our atmosphere.

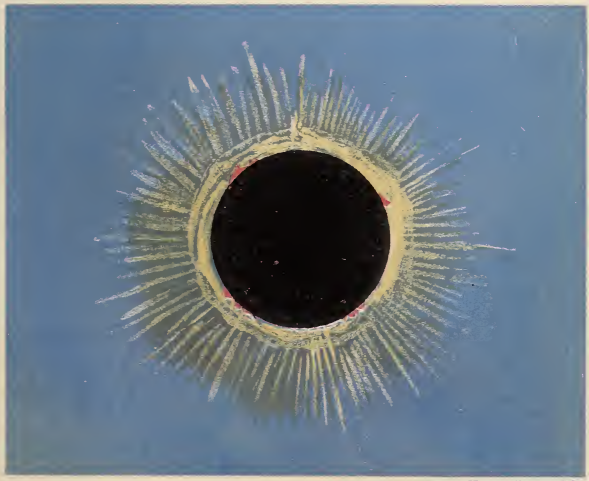
The moon is surrounded during a solar eclipse

with a luminous ring, which gives to it a very beautiful appearance. Dr. Halley, speaking of this, says, in reference to an eclipse in 1715: "Some seconds before the sun was entirely hidden there appeared a luminous ring around the moon, in breadth equal to a twelfth, or perhaps even a tenth of the moon's diameter. Its tint was a pale white, or we may say a pearly white; it appeared to me to be slightly tinted with iridescent colours." Speculation is still busy in assigning a cause for this appearance as well as the former. During future eclipses, amateurs may consider both these phenomena worthy of observation.

We will consider more fully those movements of the earth and moon which cause eclipses when we speak of the moon.

Eclipses have happened at various remarkable periods, and consequently amongst an ignorant and superstitious race they have been regarded as objects of fear. During my residence on the south-eastern coast of Africa an eclipse of the sun happened, and which I had

Partial and Total Eclipses of the Sun.



Vincent Brooks, Imp.

The red flames during Eclipses.

announced to some of my Kaffir companions. They were very incredulous that "the sun would be ill," until they saw its light begin to decrease, when they were greatly astonished. Their inquiries were original and amusing; some of the men asking why the sun was not well, others wishing to know whether it was tired, and thought it time to lie down behind the hills. When they received an explanation, and were told that in a few days the moon would be seen, and that it was her passing before the sun that caused the eclipse, they mostly comprehended the cause at once; and one man added in explanation to his hearers that the line of shadow *was* curved like the moon.

Thucydides states that there was an eclipse of the sun during the first Peloponnesian war; and Plutarch informs us that Pericles had some difficulty in persuading the men who were on board his galley to accompany him, as they feared that the sun becoming dark was an evil omen. The great battle of Arbela was fought eleven days after an eclipse, and thus the date

of the battle becomes known by a reference to the lunar and solar tables. The following are the *principal* eclipses of the sun which will be visible in England during the next forty years:—

1865	October 19th....	4 P.M.
1867	March 6th.....	8 A.M.
1870	December 22nd..	11 A.M.
1874	October 10th....	9 A.M.
1887	August 19th	3 A.M.
1900	May 28th	3 P.M.

There will be other eclipses visible, but merely very partial ones.

CHAPTER III.

"What song the Syrens sung, and what name Achilles assumed when he hid himself among women, although puzzling questions, are not beyond all conjecture."

From the region of facts we pass to that of conjecture, and we will now consider the probable condition of our central orb.

It is frequently considered a sign of mental weakness to deal with speculations, whilst to collect facts is a proof of sound sense. To speculate when we have no grounds upon which to build is certainly injudicious; but to compare probabilities, and to reflect upon the evidence, or upon the condition of the unknown, is a proceeding not unlikely to lead to the discovery of truth.

Sometimes we find that individuals have been designated speculators, simply because

they differed from the speculations of those who had preceded them, and who imagined that their theory or speculation must rest upon incontrovertible facts. Thus we usually find that the sound, close reasoners of the early ages were designated by certain men visionaries and speculators, whereas these characteristics in reality belonged to those who believed their positions secure and immutable.

The earliest scientific men speculated upon the form of the earth; they agreed that it was flat, and that it rested upon water. Those who at a later period disagreed with this hypothesis, and believed that the sphere was the more true form, were regarded as speculators and visionaries, with whom it was useless to reason.

In quite modern times the geologist was looked upon as a visionary, and who, like Galileo, was accused of an attempt to disprove Scripture. Now, however, when men's minds are more enlightened, it is found that these very facts revealed by geology prove more

than ever that an all-powerful Creator, whose wisdom is unbounded, must have made the earth and all it contains upon a prearranged system.

It is almost impossible to name any subject upon which there have not been some opinions formed: when, therefore, we speculate upon these subjects, and come to a different conclusion to that previously arrived at, it is merely one idea opposed to another, and we must then consider the probabilities affecting each.

Thus a speculation upon the unknown should not be widely or gratuitously condemned, more especially when certain notions are accepted as true, and which are in themselves merely speculations. The cause of the sun's heat is a subject which must possess considerable interest, but which is one coming within the bounds of speculation only. We have therefore to consider the probabilities connected with the cause of this heat; and as a preliminary step we may reflect upon some of the various methods at

present known, and by means of which heat is produced.

First we have the common method—viz., by means of fire. It is here necessary that some description of fuel should be supplied, and we are not aware of any means by which a great fire can be maintained except by the aid of fuel.

Secondly. Heat may be produced by means of friction, and according to the conditions under which this friction takes place, so the heat evolved is great or otherwise.

Thirdly. Great heat is produced in many substances when a current of electricity is passed through them: thus platinum, silver, and substances in which sulphur is contained, will usually become very hot when they are employed as conductors.

Fourthly. During many chemical changes great heat is produced and evolved by certain combinations in various substances.

These are all simple methods of producing heat; how many more ways there may be it is

impossible to say, although it is probable that there are many more, for it is not likely that we have just now reached the end of discovery connected with heat.

We may next consider the various facts connected with the heat of the sun; and amongst others we find that when the sun is nearly vertical we feel more heat than when he is near the horizon; that if we ascend to the summit of lofty mountains we obtain less heat, although the sun may be directly overhead. Even from these two facts we are taught that the heat of the sun is dependent in a great measure upon the state of the atmosphere through which the rays pass, and upon the angle which these rays make with the earth's surface.

There is no evidence which should induce us to think that the sun is a great fire, or that it is in itself any hotter than is our earth. The particles of which the sun is composed may be charged with, or they may be producing great quantities of a subtle force somewhat similar to electricity. This force, or power, may produce

no effect on space, but when it enters an atmosphere it may at once produce heat and light. We know that a gun may be fired by means of electricity, although it may be at the distance of twenty or thirty miles from the battery. The battery itself is quite cool, and so is the copper wire which conducts the electricity. When, however, this subtle current traverses a piece of platinum wire, the wire instantly becomes red hot, and the gun can be fired. If a person were ignorant of the law that the heat induced in any substance by the transmission of an electric current was dependent on the conducting power of the substance, he might imagine that the battery itself must be at a fearful heat in consequence of the wire twenty miles distant becoming red hot.

Hence it is not improbable that our great central orb may be a cool summer residence, but possessed of a power which is not (at least yet) manifested by the various planets in the system.

It is not improbable that according to the atmospheric or other condition of a planet, so

may it be able to gain great or little heat from a certain quantity of the sun's rays.

It is absurd to build any theories upon the supposition that because a planet is at a great distance from the sun, that therefore it must be very cold, and *vice versâ*. We may be sure that the architect of the universe made some arrangements to overcome this, to us, apparent difficulty.

The planet Jupiter is far brighter and appears even better lighted than does the planet Mars; and yet the former is not so near to us as is the latter by about three hundred and forty million miles, and Jupiter is rather more than that number of miles farther from the sun than is Mars.

It would be indeed singular if our little earth were the only orb in the system with a climate suitable to what we know of organic life. When, however, we consider that the heat derived from the sun may be dependent upon the condition of a planet's atmosphere, we see no difficulties in our way.

Another singular fact which is interesting is that the sun rotates upon its axis.

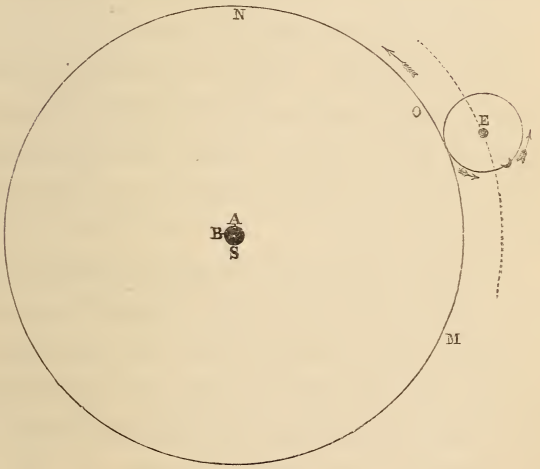
To assert that any great work of nature is not made for some definite purpose is very like an endeavour to libel creation. Surely, then, this rotation must be for a purpose; what that may be is a subject for conjecture.

Upon observing the different members of the solar system we find that they all move round the sun and in the same direction, the sun itself rotating in the same way as the planets revolve. Thus the various planets seem to roll round their orbits, and in the same direction that the sun itself rotates. The rotation of the sun appearing to carry the planets onwards in their course. That which is very remarkable is, that just as the sun appears to turn the various planets around him, so do the various planets turn their satellites around them.

If now we consider the improbability of eight primary planets, about sixty smaller planets, and upwards of a dozen satellites all following this rule *by chance*, we at once perceive

that these movements must be obedient to a law.

The following diagram will explain the joint movement of the sun and a planet, and will also show a curious fact connected with the earth's



movement and the distance of the moon. S represents the sun, which turns round from A to B. M O N is the earth's direction of movement.

If now we suppose E the earth, about which

a circle is described with a radius of about two hundred and forty-five thousand miles, and then cause this circle to roll like a wheel around M O N, then the earth would turn round just as often as it does every year, to perform its annual course: the radius of the small circle is nearly the mean distance of the moon from the centre of the earth. Thus if we considered the earth the nave, and the moon's orbit the tire of a wheel, then this wheel would roll around the sun at their present distances, in as nearly as possible 365 days.

From the experiments of various philosophers it has been shown that, when a magnet is made to rotate upon its axis, it will cause many substances near it, as well as gases, to rotate also. It is not necessary that the substances should be themselves perceptibly magnetic; for clay and wood have been found to be thus influenced. May it not be possible that the rotation of the sun causes in some way the rotation of the various planets? and may we not have become acquainted with *an effect* only,

when we speak of gravity, and the laws of gravity? The individual who observed the effect of an electro-magnet, might possibly at first overlook the fact that the battery was the instrument as well worthy of study as the piece of iron which attracted the various metals placed near it; for the more we can trace effects to other effects, the nearer we must be to causes.

The sun is spherical, and rotates upon an axis, and thus bears a strong likeness to the planets. A question which naturally arises here is, whether the sun is entirely independent as regards its source of heat-giving power; or is it connected by some subtle means with another orb? Is the sun, in fact, a planet to some other sun? and is our earth, and are the other planets, but the satellites of our sun?

We have seen that there is good reason to believe that the spots on the sun produce some effects of a magnetic and electric character upon our earth; and we are by this fact prepared to believe that there are agencies at

work in the universe of a subtlety and power beyond our present knowledge or experience. Thus the sun may be influenced in a measure by some distant twinkling star, which is yet a mysterious link between our sun and other portions of creation.

If there were an inhabitant on one of Neptune's satellites, he might not think much of the influence of our sun upon his primary planet, and he might be sadly puzzled to account for the variations in light and darkness which occurred.

Some observers have supposed that the two hemispheres of the sun do not give an equal quantity of light. If this belief be a truth, it would give some probability to the supposition that the sun is not entirely independent; for we might conclude that there was a summer and a winter on the sun, and thus that one hemisphere (the brightest) was then enjoying summer, and the other possessing winter.

Vincent Brooks, lith

THE MOON
SIX DAYS OLD.

CHAPTER IV.

THE MOON.

NEXT to the sun, the moon is the celestial object which attracts the greatest attention. From the earliest ages the moon has been considered a mysterious body; wielding influences over men's minds, and over the weather, and causing strange vagaries to be played by the otherwise orderly course of nature.

It is not at all surprising that the moon should have been considered mysterious in an age when mystery was preferred to simplicity; for her movements and condition, even in the present age, are subjects about which some uncertainty exists.

To the casual observer, the moon's changes and movements appear hopelessly intricate; but when we obtain a key to these, we find that

simplicity takes the place of apparent confusion; and that the lunar machinery, like all Nature's works, is arranged upon the most beautiful and orderly system.

The moon first appears like a thin crescent, and close to the sun. The side nearest to the sun is that which is illuminated. Soon after the sun has set the moon also disappears beneath that portion of the horizon near where the sun set.

If the evening be fine and clear, not only will the thin bright crescent of the moon be visible, but also the whole round body, which appears of a pale-yellowish tint, and somewhat smaller than the bright crescent.

The moon is a body which gives out little or no light from itself, but merely looks bright in consequence of its reflecting the sun's light. Thus, when it appears in the heavens as a thin crescent, this appearance arises from the greater part of the sun-lighted portion of the moon being invisible to us.

The paler light of the remaining portion of

the moon is due to the reflected light of the earth, which then shines on the moon just as does the full moon upon the earth.

We must remember that, when a ball is shone upon, half the surface of that ball will always be lighted; and, just as we stand with reference to the ball, so can we see the lighted portion as a thin crescent, a semicircle, or a circle.

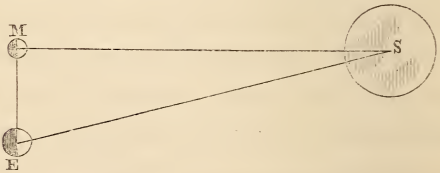
When we see the moon as a thin crescent, that part upon which the sun shines is only partly turned towards us, and the earth, the moon, and the sun are nearly in the same straight line.

If we watch the new moon, we shall find that each night the crescent will appear larger and larger, until the bright portion is of a semicircular shape. During these changes it will be found that the moon moves farther from the sun each night; and, instead of setting immediately after the sun, as was the case when she was in the thin crescent form, she will now be nearly to the south when the sun is in the west.

When the moon is half enlightened, or rather when we see the half of the lighted part of the moon, then a line drawn from the sun to the moon will be at right angles to one drawn from the moon to the earth.

The ancient astronomers were aware of this fact, and they suggested a very ingenious method for determining *the relative* distance from the earth of the moon and the sun.

They watched until the moon appeared an exact semicircle: they then measured the number of degrees between the moon and the sun, and they thus had a right-angled triangle, as follows:—



M was the moon, E the earth, and S the sun. The angle S M E they knew must be a right angle; the angle M E S they measured, and consequently they knew the proportional dis-

tance of M E and E S; for the three angles of any plane triangle make 180°. Thus they could find the angle M S E. Then by rule of three—

As the sine of the angle M S E
Was to the distance M E,
So was the sine of the angle E M S
To the side E S;

and thus the proportion between M E, the moon's distance, and E S, the sun's distance, became known.

There is sometimes a great difference between theory and practice, and so it proved with this problem; for the ancients came to very different conclusions, in connection with the relative distances of the sun and moon, from those which are accepted in the present day. The idea nevertheless was ingenious, however uncertain were the practical results.

The enlightened portion of the moon will each night appear larger and larger, and she will move farther from the sun, until she is quite circular. At this period the earth, moon,

and sun are in a straight line, the moon being on one side of the earth, the sun on the other.

When the moon is full, she rises at nearly the same time that the sun sets, and sets at the same time that the sun rises.

The same changes take place during the decrease in apparent size of the moon that occurred during her increase, except that it will be the eastern side that is now illuminated, instead of the western. So that, if we stand facing the moon, we shall see the right-hand side illuminated during the time that she increases in brightness, and the left-hand side when she is decreasing.

Just before sunrise we may observe the moon like a thin crescent, just as we see her at times after sunset when she is new, the opposite side being now bright.

The moon, like the sun, sometimes appears of a large size on the horizon, and of a deep red tint, and her colour and brilliancy vary considerably. These effects are most probably due to changes in the atmosphere of the earth.

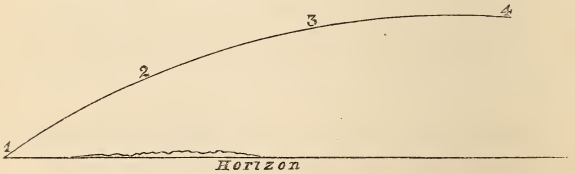
When we know that it is the sun that causes the moon to seem bright, there is an appearance in the moon which at first sight is paradoxical. This is, that if we draw a straight line from the sun to the moon, the illuminated part of the latter does not at all times appear at right angles to the former, as it ought to do. This becomes most apparent when the moon is about half full, and is about south-east when the sun is south-west. The following sketch will show the appearance referred to.

This is due to the horizon being *apparently* a straight line, whereas it is really a curve; and as we refer the line between the light and darkness on the moon to the horizon, this line appears not to be perpendicular to the former.

All the celestial bodies appear to describe

circles in the heavens, although they may remain stationary; and thus *any portion* of the apparent course of a celestial body appears to be part of a circle.

If the moon, instead of being a spherical body, were a long attenuated body, she would appear in the heavens like a bow. We can easily see how this would be, if we observe where the moon rises, and where she is at various times during the night. Then, if she were a long thin body, the various portions would extend in a curve from the eastern horizon to nearly the south, much in the manner shown below.



1, 2, 3, 4, here represent the various positions of the moon at different times during the night. Then, if the moon were a long thin body, it would appear as shown by the line 1, 2, 3, 4.

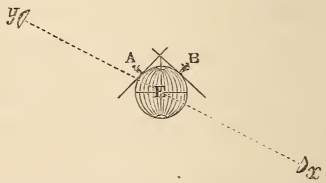
This is the reason why the tails of comets most frequently appear curved.* If, however, a person were in the central portion of the earth when the moon passed directly overhead, this same line would appear to be straight, just as a bow would appear straight if held with the bow-string towards us. Thus a comet's tail might appear bent to an observer in the northern or southern portions of the earth, but quite straight to an observer near the central latitudes. The bending being dependent upon the direction of the comet's tail in the heavens in connection with the horizon.

If the moon be observed during several nights, it will be seen that her height above the horizon varies considerably. Sometimes

* It has been remarked by several observers that the tail of the great comet of 1861 was straight, and that this was a peculiarity. The fact was that the appearance was due to the position of the tail, which extended from the horizon to the zenith. If the tail had extended from east to west and over the equator, then to an observer in the north or south the tail would appear curved; but if the tail were near the zenith—*i. e.*, if an observer were at the equator, it would at the same time seem to him quite straight.

she rises and passes to the south with a less altitude than the sun has during midwinter. Then, in less than a fortnight, she will pass to the south with a greater height than has the sun during summer.

The reason of this is, that the moon moves around the earth in about $27\frac{1}{3}$; days and thus, during the half of that period, a change in the altitude of the moon takes place, just in the same manner as a change in the sun's altitude occurs in six months. The following figure may aid to explain this fact.



E represents the earth; the direction of the north pole of which is indicated in the sketch. A and B are two positions of the same observer on the earth's surface; x and y represent two positions of the moon, so that, if x be the moon's place on any day, then fourteen days

afterwards the moon will be in the position shown by *y*.

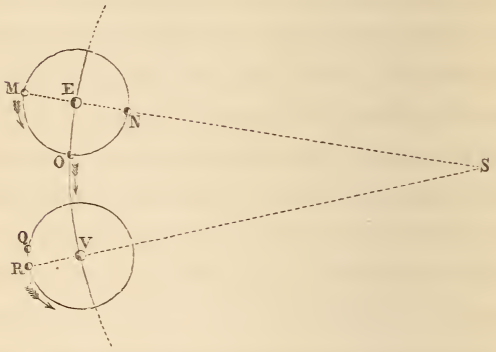
To the observer when at B, the moon will appear very low down, and near the horizon; but when he is at A, and the moon at *y*, then she will appear nearly over his head.

There are several other changes which occur in the apparent height of the moon, but these are beyond the range of the present book.

We remarked that the moon moved round the earth in about 27⅓ days. This, however, is not the interval between two full moons or two new moons, &c. The period between two full moons is about 29½ days. This difference arises from the fact that, whilst the moon moves round the earth, the earth moves round the sun. If the earth stood still, then the moon would become full at intervals of 27⅓ days.

Thus, in the following sketch, S is the sun, E the earth, and M O N three positions of the moon, which at M is full, at O half full, and at N invisible. If the earth remained at E, and

the moon moved round from M to O and to N, then the intervals between the full moons would



be just equal to the time of the moon's passage round the earth.

If, however (as is the case), the earth moves on to V, then the moon will have moved round the earth, and will have reached to Q in $27\frac{1}{3}$ days, but she will have to move on to R before she appears "full," and it occupies her rather more than two days to move from Q to R.

The shorter of these two periods is called *the sidereal revolution* of the moon, the longer *the synodic revolution.*

In consequence of the earth turning round on its axis, we have an alternation of day and night; and if there were an observer on the sun, every portion of the earth would be visible to him once in twenty-four hours. The moon does not turn upon her axis in the same manner as does the earth, for only about one half of the moon has ever been seen by man. This arises from the fact that the moon turns round in exactly the same time that she moves round the earth.

If we were to stick a sword into a large apple, hold the sword with the apple on the point at arm's length, and then move the sword around us, we should only observe one half of the apple, and the apple itself would not spin upon its axis like a top. Just so is it with the moon, which always turns one face towards our earth.

In consequence of the moon revolving round the earth, she is of course lighted on all sides by the sun, and thus during about twenty-nine and a half of our days the moon has one day

and a night, so that her day is rather longer than fourteen of our own.

If our earth were to move in a similar manner to the moon, only a little more than one half of the earth would ever see the sun, whilst the remainder would be in darkness, and thus there would be no evening and morning, and no alternation of day and night.

Some singular ideas are forced upon us when we consider this subject, and find that in the Mosaic account of the earth's earlier histories, there was a period when there was darkness upon the face of the deep, for it appears by this, that the evening was, and the morning was, *after* the first condition. It would be singular if in the vast ages to come the terrestrial inhabitants were to find the moon bestirring herself, and turning on her axis like the earth. Yet this change cannot be pronounced impossible, in consequence of our utter inability to explain the cause of the rotation of a single planet in the system.

The moon follows the same law in her revo-

lution that the various planets follow; viz., she moves round the earth in the same direction that the earth rotates: thus the earth appears as it were to drag the moon round her, just as the sun appears by his rotation to drag the planets around him.

The moon, when examined with the naked eye, appears to present a smooth and regular surface. There are dark patches in various parts, which assume the form of a man's face, but there does not seem to be any great irregularities on the moon itself. When, however, we direct a telescope of moderate power towards the moon, a strange scene is presented to us; the curious face-like appearance disappears, and we observe a collection of light and dark patches, streaks of light or shade, circular lines, and all the varieties of a volcanic and mountainous district on earth.

That portion of the moon which borders on the dark part is covered with long shadows, whilst here and there brilliant peaks shine against the dark background. Occasionally

two or three star-like objects become visible near the borders of the enlightened portions of the moon, as the sunlight is reflected from the most lofty mountain summits, which are illuminated before the less elevated localities near them. Huge craters and long ravines, gentle slopes and clusters of mountains, all become visible with the aid of the telescope. The appearance presented by the moon's surface is like that of a vast volcanic district, where igneous action has only just ceased, and where the forces at work have been much greater than upon our earth. Some of the largest craters on earth are not one tenth as large as those on the moon. Thus Teneriffe scarcely exceeds nine miles in diameter, whereas a crater in the moon called Clavius measures about one hundred and forty miles.

Some of these lunar craters are circular, whilst others are very much elongated. They are best seen when the moon is only partially lighted by the sun, and when consequently the

sides of the crater cast shadows upon the surrounding hollow ground.

Mountains and valleys, hills and dales, are observed on the moon; but there does not appear to be any indication of large seas, or even water. Recent observations have led to the belief that there is vegetation on the moon, at least at times, but this statement requires confirmation.

It is very easy to see, that if we know the length of shadow which an object casts, and the angular position of the light, that we can ascertain the height of the object. This fact has led to the investigation of the heights of the mountains in the moon; and some very elaborate tables have been constructed, showing the altitude of the various mountains.

There is, however, very little dependence to be placed upon these conclusions, however ingenious they may be, for it does not in the least follow that the highest mountains should cast the longest shadows; and the various altitudes assumed for the lunar mountains

are calculated upon the supposition that they do.

For instance, upon earth the Himalaya mountains are the highest. These mountains are not very abrupt in parts, but they slope gradually upwards, and therefore they would not, with the sun in any position, cast a very great shadow. And if we observed the earth from the moon, the Table Mountain, which rises abruptly, would cast a longer shadow than the Himalaya mountains, and would therefore, upon the above assumption, be supposed much higher, whereas in reality it is not one-sixth the height.

The length of shadow cast by a lunar mountain will merely give the elevation of that mountain above the surface immediately around it, but it will not give the relative altitude of the various mountains above a fixed datum.

When we consider the preceding reasoning, it induces us to believe that the mountains in the moon are much higher than any on the earth, for some of the elevated peaks are found to be

nearly twenty-five thousand feet above the surface in their immediate neighbourhood, and thus they may be several thousand feet more above the lowest ground.

If it be a fact that the moon is not possessed of any seas or lakes, it appears only in accordance with terrestrial conditions that there should be very great irregularities on her surface; for if the earth had no sea there would be some deep ravines and mighty peaks exposed to view in various places where the ocean now exists.

The outline of the moon is somewhat jagged and irregular, but not to so great an extent as might be at first supposed. The approach to uniformity arises from the fact before mentioned, that we should merely observe the projection of certain peaks beyond the surrounding ground, and thus, although there would be irregularities in the outline, still these would not be so very marked.

The surface of the moon appears to have been considerably disturbed, and torn by various

forces. The deep craters at once show this. There is, however, another action apparently at work, and which produces stars and rents, just as when the ice has been broken by a skater. These flaws appear to indicate that there has been, or is, some upheaving force going on in the lower strata of the moon, and which causes the surface to crack and separate at the lines of least resistance. In fact, there would be in the moon numerous flaws in the strata similar to the "faults" in the lower deposits of our earth.

We have not to search far before we find a probable cause for the highly volcanic condition of the moon's surface. Any traveller who has passed a day upon the burning plains in tropical regions, when the sun at midday is in his zenith, and when he is exposed to the sun's rays only twelve or fourteen hours, can imagine the state in which the soil and air would be were the sun to remain twelve or fourteen *days* above the horizon. This is the condition of each portion of the moon's surface, which is exposed during about a fortnight to the con-

tinued rays of the sun, and then, during a like period, the sun is invisible.

It is only reasonable to suppose that whatever may be the condition of the lunar atmosphere, and the other agencies appertaining to her, still the sun causes heat upon her surface, and during his absence there must be cold. A very great alternation of climate, therefore, occurs upon the moon during every month, heat and cold being both very intense; and these great changes, and the long-continued action of the sun, it is highly probable would produce volcanic action, especially if just beneath the lunar surface there are rocks containing sulphur, or other non-conducting matter.

It has long been a subject of discussion whether there are any volcanoes now burning in the moon. Some observers have come to the conclusion that they have seen luminous points, which could not be accounted for in any other way than by supposing these to be active volcanoes. Other observers deny that there is any evidence to prove that volcanoes

are at present active, and that which individuals have supposed to be a volcano, was merely an illuminated peak.

In controversies of this description it must be borne in mind that no amount of negative evidence is sufficient to disprove one fact, and thus if half a dozen careful observers have seen appearances which may be fairly assumed to be active volcanoes, it matters but little whether half a hundred individuals have never seen anything of the kind. It certainly appears reasonable to suppose that there is igneous action going on upon the moon's surface, when we consider her appearance, and the amount of sun heat to which she is exposed. We ought to look for active volcanoes after the moon is full, as she has then been exposed to a continuance of sunlight for a long period: thus when the moon is south, at about 2 or 3 o'clock A.M., is the best time.

If there be any very great changes occurring upon the moon's surface, these ought in the course of a few years to be discovered. Photo-

graphy is an artist who neither flatters nor tells falsehoods, and now that a photograph of the moon can be taken, and when this photograph can be placed under a microscope, we may collect a variety of lunar portraits, which, handed down to posterity, may serve to clear up this otherwise questionable problem connected with the geology of the moon.

It has been remarked that when the public are left to themselves, they will frequently, by a sort of intuition, come to correct conclusions upon even abstruse subjects. We must, however, take care that we do not confound this sort of intuition with opinions which are the result of a bias being given to public opinion by self-elected authorities.

The earliest almanacs invariably connected a change of weather with a change of moon, and thus a bias was given to public opinion which might not otherwise have expressed itself.

There is to the loose reasoner something remarkably agreeable in the vagueness of the terms "change of weather" and "change of

moon." What does change of weather mean? From wet to fine, from fine to wet; from cloudy to clear, from clear to cloudy; from damp and foggy to dry and frosty; from a cold north wind to a mild south wind; from a nipping east to a soothing west wind; from snow to rain, from thunder-storm to calmness; from a hurricane to a gentle breeze—are all changes of weather. Then a change of moon, what is this? First, the moon is invisible, then there is a new moon. This is a change. Then the moon is half lighted, then she is full, then she is half-lighted again, then invisible. Thus, once a week, the moon "changes." Now it would be indeed strange if some change of weather, *in some localities*, did not occur at or about some of the periods when the moon changed.

We have mentioned different localities, and this is an important consideration, for if we compare the weather in even various parts of England, we find but little uniformity at the same time. If the climate of England be com-

pared with that of the Continent, still greater differences will be found. Which locality, then, is to be taken as *the* one which is affected by the change of the moon?

In consequence of observations having been carried on in various places, different conclusions have been arrived at by different scientific men in connection with the influence of the moon on the weather. Thus observations carried on at Stuttgard and Paris gave different results from those which were made at Poitevin. M. Gasparin found, according to M. Arago, that there was the least rain between the full moon and the last quarter, whereas at Stuttgard the least rain was found at the period of the new moon.

From a consideration of the various facts collected by different experimentalists, it appears that if the changes of the moon do produce any influence upon the weather, the results of these influences do not cause so great a change, as the local conditions surrounding different places.

We are upon tolerably safe ground when we assert that the moon causes some of the tidal changes upon earth, and that consequently she attracts the waters of the ocean. Granting this, we do not find it impossible to believe that when the atmosphere is imbued with a large amount of moisture, that she would attract the atmosphere in a manner somewhat analogous to that in which she attracts the ocean. When we have to consider attraction, we have a very subtle force to deal with, and conjecture must enter largely into the investigation, whilst positive certainties cannot be obtained. Dealing then merely with conjecture, it becomes a question whether, when the moon thus attracts the waters of the ocean or the atmosphere, she draws from either any of those elements of which water is composed. We find that attraction will act at the distance of many millions of miles, and it is not, therefore, like any material forces with which we can deal. It might be then, that when the moon is thus attracting the ocean, she is, by means of the

subtle chemistry of nature, drawing from it some of the elements of which she herself is deficient, and thus she may be forming an atmosphere, or obtaining moisture which will, by the action of the sun's heat, enable her to produce an atmosphere.

This action may be, according to human ideas, very slow; still, if it exist, we should find our moon passing from its present hard granitic and volcanic state, into a condition which would admit of vegetable and animal life of a low order being created upon its surface; and thus a geological change would be marked. Perhaps also this long sun period of fourteen days might, when the moon possessed an atmosphere, be suitable for the growth of plants which did not produce hard wood; and thus ferns would predominate, which would cease to live immediately the sun ceased to shine upon them. Their fall would be probably attended by a deposit of snow, which another long day would melt, and thus growth of ferns might follow growth of ferns, and layer after layer of

vegetables might be deposited, which would eventually perhaps become the coal beds for those who were created upon the moon, when its youth had advanced towards maturity.

In the absence of certainty we can only deal with conjecture.

Another subject of discussion connected with the moon is, whether or not she possesses an atmosphere similar to the earth. There is reason to believe that if the moon possessed an atmosphere, then, when any stars passed the limbs of the moon, their shape and appearance would be considerably altered. As might be expected, phenomena of this description have been carefully watched; and there are few individuals provided with a telescope of even moderate power who have not observed several such transits. Some difference of opinion naturally exists as to whether the star or planet has shown any variation as the moon passed before it; but the majority of observers agree in the belief that no change is produced. It is assumed that the atmosphere of the earth does

not extend beyond forty-five miles from the surface; but this is merely an assumption. An atmosphere of a rarefied character may extend to any distance. In fact it is difficult to say to what extent the earth's atmosphere may extend; and it is possible that the moon may be within the radius of the earth's atmosphere; and thus there may be a means whereby her volcanoes only smoulder, as it were; whereas, if there were a more dense atmosphere, these would burst out into fierce flames. We should of course find no alteration in the appearance of a star as the moon passed it, if the moon were within our atmosphere, unless immediately about the moon, the air was much more dense.

When we observe the incomplete or unfinished state of the moon, and then regard the present condition of our earth, it is difficult to avoid the conclusion that the moon is the *younger* of the two. There is an appearance about the moon's surface very similar to that which the earth must have presented during that early geological period, when granite or

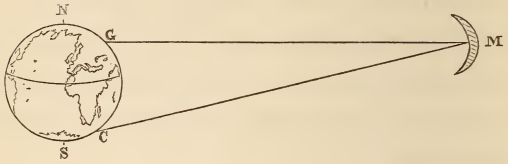
gneiss were the surface soil, and when there were not yet conditions sufficiently favourable to organic life to admit of the existence of any beings of a higher type than a few worms or zoophytes. When we consider this probability, and when we regard creation from an expansive point of view, we are irresistibly struck with the singularity of the statement of Lucian and Ovid, who both inform us that the Arcadians asserted that their forefathers had inhabited the earth before it possessed a satellite. Some objectors, who are more ready to raise an objection than to weigh the soundness of their arguments, have believed that they had exposed the absurdity of this statement when they said, "Then the moon must have been a comet, and if so, *what has become of its tail?*" This weak objection is so readily answered, that it is surprising that it was ever urged; for we might remark that the moon, *if* an old comet, has done with its tail, just that which the comet of Encke has done with its tail; for this short-period comet exhibits no tail, and when nearest the sun it

has a diameter not one-tenth of that which it has when at its greatest distance. Thus the approximation of its particles appears to be connected with its distance from the sun; but it does not necessarily follow that the moon was a comet: it might have been formed in several other ways.

A statement such as that of Ovid is not to be hastily disposed of, either by ridicule or an off-hand objection; but probabilities must be weighed, and guesses should not take the place of facts.

The distance of the moon is more readily obtained than is that of any other celestial body, in consequence of her nearness to the earth. Two localities situated in distant parts of the world are chosen as points for observation. The latitudes of these two stations being known, the distance in angular measure of the moon, from the north pole and from the south pole, may be obtained. Thus, if G and C were two points upon the earth's surface, such as Greenwich and the Cape, then the angular distance

of the moon from the south pole of the heavens, added to the angular distance of the moon from



the north pole of the heavens, will exceed 180° by exactly the angle G M C.

The distance in miles between G and C is known. The two sides M G and M C are so nearly equal as not to interfere greatly in the question, and thus the angles M G C and M C G are known, consequently the sides M C can be found by simple trigonometry.

It will also be evident that to an observer at G, the lower portion of the moon might appear to just touch a star, whilst the same star would appear at some distance from the moon to an observer at C. Hence another means is afforded for finding the distance of our satellite, which amounts to about two hundred and forty thousand miles; a short distance when compared to

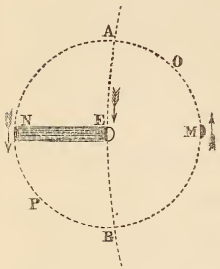
that of other celestial bodies, but still one sufficiently great to occupy an express train travelling at fifty miles an hour, rather more than three months to accomplish the journey.

As soon as the distance of the moon is found, her size can be ascertained; and she is quite small when compared to the earth; her diameter being only about two thousand one hundred and sixty miles.

An eclipse of the moon lasts a much longer time than an eclipse of the sun, first, because the earth is larger than the moon, and secondly, because when the moon is eclipsed, both she and the earth are moving in the same direction, but when the sun is eclipsed, then the two are travelling in opposite directions. The following diagrams will explain this:

Suppose S the sun and E the earth, which, with the moon, is travelling in the direction from A to B; M the moon, during a solar eclipse, is travelling round the earth from M towards O, and thus moves in one direction whilst the earth is moving in the other. During

a lunar eclipse, however, the moon will be at N, and will then be moving from N towards P, a course which at N is nearly the same as that



S.

which the earth follows. Thus the moon remains some time longer in the earth's shadow, and consequently prolongs the lunar eclipse.

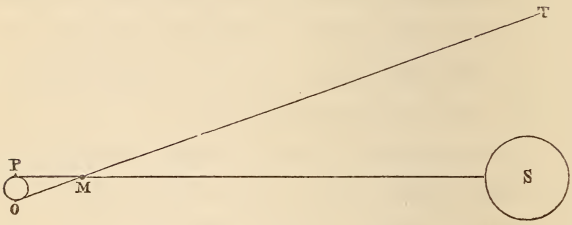
To produce either a lunar or solar eclipse, it is evident that the earth, the moon, and the sun must be in the same straight line. In consequence of the moon moving around the earth in about twenty-nine and a half days, these three bodies must be twice during that period in nearly the same straight line. Thus it may appear at first sight singular that during every twenty-nine and a half days, there should not

be an eclipse of the sun and moon. The fact however is, that the moon only *crosses* the actual path of the sun twice during her revolution round the earth; if therefore she does not cross this path either when she is full or invisible, then no eclipse can occur.

There may be seventy eclipses observed in different parts of the world during a period of eighteen years; of these, forty-one are solar eclipses, and the remainder (twenty-nine) are lunar.

In consequence of the proximity of the moon to the earth, eclipses of the sun may be seen in some parts of the earth as total eclipses, in other parts as partial, whilst in others the eclipse is invisible. In this respect an eclipse of the sun differs from a lunar eclipse. Whenever the moon can be seen above the horizon during the time of an eclipse, then also the phenomenon can be observed; but it is not so with the sun, which, although visible at the same instant to two observers, may be partially eclipsed to the one but not to the other. The

reason of this may be understood from the following diagram:



Suppose S the sun, P O the earth, and M the moon. An observer standing at O upon the earth's surface, would see the moon in the direction of T, far above the sun; therefore to the locality O the sun would not appear to be eclipsed. The observer at P, however, would see the moon in the direction S; that is directly between him and the sun, which would consequently be totally eclipsed.

As the sun would not be eclipsed to the observer at O, whilst it would be totally hidden by the moon at the point P, it is evident that if observers were placed at various stations between P and O, they would see the eclipse

nearly total, or partial, according as they were near to P or O.

When the moon is eclipsed, the phenomenon is due to the earth's shadow, and this shadow will not alter its apparent position, although an observer may alter his. Thus a total eclipse of the moon will be a total eclipse at all places where the moon is above the horizon, and a partial eclipse will be a partial eclipse. Thus there is no necessity to travel to different parts of the world to obtain a better view of a lunar, although it may be to see a solar eclipse.

If we take any particular locality upon the earth's surface, we shall find that more lunar eclipses are visible from that locality than there are solar, because the duration of a lunar eclipse is greater, and it is more likely to be visible than is a solar. Taking the whole world, however, three eclipses of the sun will occur to two of the moon.

The best time for observing the surface of the moon with a telescope is during the first quarter. She will then be visible in the south-

western portion of the heavens as soon as the evening is sufficiently advanced to enable us to see her without difficulty. The sun is then shining upon the moon, so as to enable an inhabitant of the earth to see distinctly the shadows cast by the lunar craters. These craters vary in size and form; some are very large, being as much as one hundred and forty miles in diameter: many of them appear to have a small opening or aperture in the centre, which is surrounded by a ridge, or this appearance may be merely a peak in the centre of the crater. Even during one night a considerable change occurs in the appearance of a crater, in consequence of the rise of the sun, as the shadow cast by the side of the mountain will decrease, fresh peaks become illuminated, and various irregular lines of hills appear to alter their form. Much of the beauty of contrast produced by the variation of light and shade is lost when the sun shines nearly vertically upon any part of the moon; thus the full moon is not so interesting an object for exami-

1. Craters on South of Moon.
2. Craters West of Appennines
3. South of Moon.
4. Alphonso &c. near Mare Nubium.
5. Posidonius.
6. West border of Mare Imbrium.
7. Maurolycus.
8. Appennines.
9. Tycho

nation as is the same orb when about one-third of the illuminated surface is directed towards the earth.

On Plate 5 are sketches of various portions of the moon's surface taken at different periods. These sketches have been made with a small but very good telescope, and may serve to show the great irregularities upon the face of our satellite.

On Plate 4 is a diagram of the moon taken when she was partly visible. It will be seen from these that the lower and left-hand side of the moon are those parts which seem to be the most covered with craters.

CHAPTER V.

VENUS.

The celestial object which appears at times the next largest to the moon, is the planet Venus. The brilliant white light reflected by this planet, and the fact of her being a morning or evening star only, and never visible during the middle of the night, caused considerable attention to be directed towards her from the earliest ages.

One of the most important steps towards obtaining an interest in the movements and condition of the various celestial bodies, is to be able to tell whether the object which we see is a planet or a star, and also which of the planets it is that we may have seen.

It is very rarely indeed that there can be any mistake in connection with the planets, and the slightest reflection will enable us to

decide when we see a planet, whether it is Venus, or Mars, or any other.

There are only two planets which appear of a large size, and which shine with a bright whitish light. These two are Venus and Jupiter. Mars, which sometimes appears as large as either of the former, always exhibits a bright red appearance, and cannot therefore be mistaken for them. In discerning therefore between Venus and Jupiter, there might possibly be some confusion, but merely at a particular period.

Venus is never very distant from the sun, and only rarely remains above the horizon more than an hour or two after the sun has set. She may rise also two or three hours before the sun. Thus she either immediately follows or precedes the sun. *But Venus is never seen at midnight* in any but very high latitudes north and south; nor is she *ever* seen of an evening in that part of the heavens opposite to where the sun has gone down. Thus, if a very brilliant white-looking celestial object is seen near

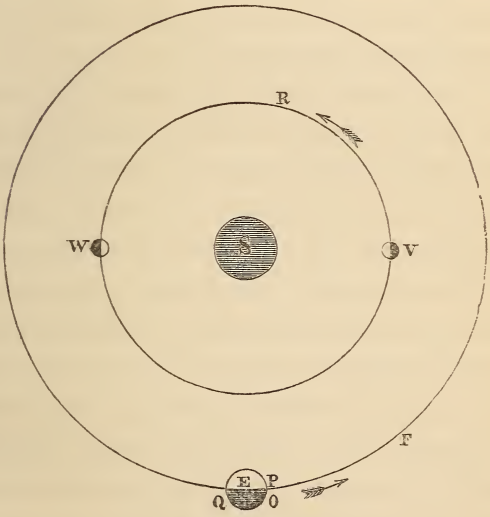
the western horizon in the evening shortly after sunset, or in the east just before sunrise, then this object is most probably Venus.

If the planet Jupiter be in the same locality he will appear smaller and less brilliant, because he will then be at a very great distance from the earth. Thus, even without any telescope, the planet Venus ought to be recognized; but with the aid of one, no mistake can occur, for reasons which will be stated at a future page. The reason why Venus is never seen very far from the sun, is, because this planet moves around him in an orbit which is within that which the earth follows. Thus the earth never is between Venus and the sun, but Venus may be between the earth and the sun.

In the following diagram S represents the position of the sun, W V the orbit of Venus, whilst the largest circle represents the orbit of the earth.

When Venus is at V and the earth at E, an observer on the earth would be carried round by the daily rotation from O to P and

to Q. When this observer was at O he would be able to see Venus at V whilst the sun was invisible; then when he had been carried to P.



the sun would be rising. Thus Venus would rise before the sun, and would consequently be a morning star. She would also set before the sun, and would not therefore be seen in the evening.

If Venus were at W, then she would rise after the sun, consequently from O and P she would not be seen, on account of the sunlight; but when the observer had been carried round to Q, the sun would be invisible, but Venus would be seen as an evening star.

Venus moves round the sun in the same direction as does the earth. She, however, moves more quickly, and has a shorter distance to travel over to perform her annual journey round the sun. If we suppose that Venus is at V when the earth is at E, then as they both move in the direction shown by the arrows, the earth would arrive at about F when Venus was at R, and she would during all this time remain a morning star. Thus this planet remains visible or invisible for a long period in consequence of the joint movement of the earth and herself.

Venus is found to revolve around the sun in about 224 days 17 hours; but she only returns to the same apparent position as regards the sun in 1 year, 3 months, and 29 days. That

is, in intervals such as this she becomes an evening star or a morning star. The reason for this, as pointed out in the preceding diagram, is her motion combined with that of the earth.

The distance of Venus from the sun is found to be about sixty-eight million miles, the earth being about ninety-five millions. Thus at times Venus comes within about twenty-five million miles of the earth, a distance much less than that which ever separates us from any other planet. Knowing the distance of Venus from the earth we can readily obtain an approximation to her size, about which, however, some slight uncertainty exists. It is generally admitted, however, that she is rather smaller than our earth, she being about seven thousand seven hundred and eighty miles in diameter, whilst the earth is rather more than seven thousand nine hundred.

Venus, which appears like any other of the planets or stars when seen with the naked eye, presents a singular difference when she is ex-

amined with a telescope. When at her greatest angular distance from the sun, she appears to be half lighted, and thus exhibits a semicircle of brightness, just as does the moon at times. If she be seen in this condition during the evening, she will in a few weeks appear to approach the sun, and will seem each night larger and more brilliant. If she be examined with a telescope when she is brightest, the size of the illuminated portion will be about one-fourth of the disc of the planet, but in consequence of her greater proximity, she appears larger than when half illuminated.

As she approaches the sun, the lighted portion becomes less and less, until at last she is lost in the sun's rays. During a few days she is invisible, and then reappears as a morning star, separates herself from the sun, and reaches about as far from him on the one side as she formerly did upon the other. When at the greatest apparent distance from the sun on the west side, she will rise about three hours before him, and if examined with a telescope will be

then found half illuminated on the side next to the sun.

The phases of Venus, as these changes in appearance are termed, are not the only interesting facts revealed when we direct a telescope of moderate power towards her. For we find that she has an atmosphere like the earth, that there are appearances upon her which lead us to conclude that she has portions of her surface covered at times with snow. We can see that she rotates upon an axis, and thus has an alternation of day and night, and also we know that she has a change of season.

If from the sea-shore we observed two ships, each of which possessed a similar hull, masts, rigging, and sails, and if from each we observed smoke coming out of a chimney, these two ships would scarcely be more alike than are the earth and the planet Venus. Each planet has an atmosphere, each is spherical, each has a day and night, a year, and a change of season. Thus when we examine Venus from the earth,

it is almost like looking at our own planet from space.

When speaking of the moon, we pointed out the fact of the whole body of the moon being visible when only a slight crescent was illuminated by the sun; and this effect, it is believed, can be explained by supposing that the earth shines upon the moon. It is singular, however, that the same phenomenon has been observed upon Venus, the whole of whose surface has been distinctly seen when only a small portion has been illuminated by the sun. It admits of question whether the reflected light given by the earth would be sufficient to produce this observed effect on a planet as distant as Venus. In consequence of the orbit of the earth being outside that of Venus, our planet would give a much brighter light upon Venus than she ever gives to us, because the earth when nearest to her would appear "full," whereas she is only seen by us as a partially illuminated body. Thus the *ashy light* of Venus might be due to the earth's light re-

flected on to her surface. It is not impossible, however, that the rotation of a planet upon its axis may produce light in some way; and thus Venus and all the other primary planets may give out a faint light, independent of that which they reflect from the sun. When examining the system of Jupiter, we will again refer to this conjecture.

That portion of Venus which is nearest to the sun, is found to be much more brilliant than the central part, where the light and shade almost meet. This is a natural consequence of the spherical form of the planet, just as the midday light on earth is greater than that in early morning, and the sunlight in equatorial regions more powerful than in high latitudes.

There is an additional obscuration of light upon Venus, which has led to the conclusion that she is surrounded by a highly refractive or dense atmosphere; a condition which it is not improbable has been produced by her great annual change of climate.

The surface of Venus is covered with darkish spots of a delicate character, and they occupy the greater portion of her diameter. Sometimes bright spots are observed upon various parts of her surface, or her atmosphere. These, however, have enabled astronomers to decide, that she rotates upon her axis, in a period of about twenty-three hours and twenty-one minutes. Thus her day is rather shorter than the terrestrial day.

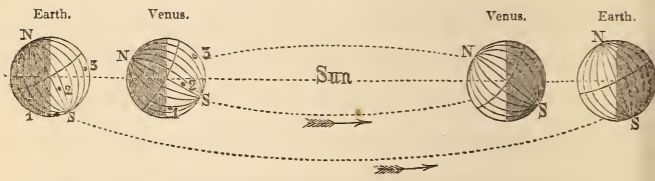
The method of discovering the time of a planet's rotation is to watch for some remarkable spot to appear upon the planet, and to correctly fix the relative position of this spot; then in some period either greater or less than twenty-four hours the spot will appear to have moved round the planet, and to have regained its first position. Some doubt might, however, exist, whether the spot had moved round only once, or whether two rotations or more had occurred during the intervals of observation. This question, however, may be settled if we observe the change which takes place in the

position of the spot during an hour or two, for we can then estimate *about* the rate of rotation, and are not likely to make any very great mistake or to confound a double with a single rotation.

In addition to the *rate* of rotation, another interesting fact is ascertained by an examination of the spots upon Venus, viz., we can find the relative changes which occur in the sun's altitude during the Venus year. This change is found to be very great, and is of sufficient interest to attract special notice.

If we examined from space the rotation of the earth during the two periods of summer and winter, we should find that the rotation took place at such an angle in connection with the position of the sun, that all localities within twenty-three degrees and a half of one of the poles were during the twenty-four hours shone upon by the sun. If, however, we examine Venus under similar conditions, we find that all localities within about *seventy-five* degrees of one of the poles are shone upon by

the sun during the twenty-four hours. The course of the spots upon the earth and Venus may be better understood by the following figures.



1, 2, 3, show the direction pursued by a spot on the earth and on Venus. When, therefore, we remember that the planet revolves round the sun, and thus turns towards it in summer that pole which was turned away from it in winter, we shall see that great variations will occur in the two seasons in consequence of the variations in altitude of the sun above the horizon. To fully understand these changes we will suppose ourselves transferred to the planet Venus, and to a locality exactly similarly situated to England upon this earth.

Here then we stand upon the surface of another world, which may or may not present

very singular variations from our own,—who shall say? We commmence our observations at that period when the sun is over the equator, in the spring of the year, a date corresponding to the 21st of March upon earth. Instead of that gradual advance from spring to summer which terrestrial beings observe, we in Venus find that the summer comes with a rush, as it were. On earth it takes three months for the sun to pass from its spring altitude to its summer, and even then it is not nearly overhead to people in England. Thirty days after the sun crossed the equator of Venus, it would at midday be directly overhead to a locality similarly situated to England.

Upon earth the only places where the sun is seen directly overhead is within tropical regions, that is, in latitudes not exceeding twenty-three and a half degrees. On earth, however, in those latitudes, the sun only remains about twelve or thirteen hours at a time above the horizon, and thus the intervals of sunlight and

darkness are equally divided; the intense heat of the day disperses itself in a measure during the night, and heavy dews moisten the ground, and thus enable the inhabitants to endure the midday heat of the morrow.

This is not, however, the condition of Venus in the regions similarly situated to England. There the sun, as we have said, is vertical at midday, but it then passes obliquely to the western horizon, glides down to the north, just touches the northern horizon, and returns again to the zenith of our locality.

Thus in about forty days after the sun has crossed the equator it would be vertical at midday, and would not set at midnight, and twenty-four hours of sunlight would have to be endured if England were situated on Venus.

From this date the sun would not set during the twenty-four hours, but would each night rise higher above the northern horizon, until in about fifty-six days it would daily describe a small circle in the heavens, the midday light

of the sun being about equal to that of our summer sun, and the midnight similar to that of spring. Thus for about thirty-two days and nights the sun would not set.

On earth we can see the midnight sun if we travel into high latitudes, but we cannot see such a sight as a midday *vertical* sun and *a midnight* sun during twenty-four hours; nor can we do more than imagine the intense heat which would be produced by such conditions as those which exist in Venus. From the period when the sun described its small diurnal circle in the heavens until it again passed the zenith at midday, and touched the northern horizon at midnight, there would elapse about thirty-two days. The retreat of the sun would be as rapid as its advance. In one hundred and thirteen days the autumn position would be reached, and the sun would at midday be no higher than he is on earth at the same period.

Just as the summer approached rapidly, so

would the winter, and in about twenty-eight days from the period when the sun was in the position corresponding to the autumn altitude in England on earth, he would be lost sight of in the same locality in Venus. A long period of some fifty days and nights would now elapse, during which the sun would be invisible, and those very localities which were so lately exposed to an ultra-tropical summer would now endure an arctic winter. There is now no light save that of the stars, and hence the cold would be as intense as was the heat. In 226 days the sun again returns to the spring position, and the yearly changes on Venus have been accomplished.

These are strange conditions to be going on in a planet so near our own; and it is difficult to avoid reflecting upon the changes which must be produced thereby. Each year an arctic winter, and a tropical summer, will alternate from her poles to within about fifteen degrees of latitude from her equator.

It would thus take some time for terrestrial beings to become acclimatized in Venus; but who can say whether the creatures which exist upon her may not occasionally suffer from these very changes?

In her equatorial regions there may be troops of giant mammoths, which, attracted by the scent of the rapidly growing vegetation, are travelling northwards, as the sun in its northward course vivifies the face of the country. Onward they stalk, farther and farther, revelling in the shade of trees which the sun's heat has produced. During a hundred days these herds track far away from the equator, and enter the now glowing lands of the north. The sun performs its daily circles, but is again returning south, and the air begins to feel chill, and darkness at midnight warns the ancient bulls that it is time to migrate.

Some members of the herds have strayed away however; their fate is sealed, for the country which but lately glowed with sun-heat

and was covered with succulent vegetation, is now a dark, bleak, snow-covered wilderness; the water is frozen, the vegetation withered, and the mammoth, crunching the dried branches, is forced to yield its life, unable to procure water, and incapable of sustaining the intense cold which penetrates even through its wool-covered hide. Many a monster might thus perish, and his bones would cumber the soil.

Another season of heat, however, would shortly return,—the snow would be rapidly melted, the pent-up streams thawed, and torrents of water thus produced would flood the country, carrying stones, sand, and icebergs with their burdens of boulders into strange regions, whilst the mammoth would be borne with the current and deposited amidst a mass of debris, near some watercourse, from which, centuries afterwards, when the planet's condition had changed, some geologist might exhume him, and speculate upon the cause which had produced such destruction amongst his fellows.

There again is a mass of rock which is annually exposed to a process similar to that said to have been adopted by Hannibal when he crossed the Alps. A vertical sun raises this rock to a great heat during an uninterrupted period of several weeks, then the sun's absence exposes it to very great cold; a change which would probably cause the rock to split and separate, thus liberating large masses, which would be each year subjected to the action of the torrents, and which probably at length would become frozen into icebergs, and transported as boulders to distant plains.

Owing to the annual alternations of climate in Venus, there must be glaciers and moraines, even upon moderate elevations, in all localities down to within about twenty degrees of her equator. Not only would these glaciers exist upon hills where they do not at present upon earth, but they would be found to produce effects more powerful than any which we can observe; for the effect of the vertical sun in summer over regions covered with snow would be very

powerful. If our polar regions were subjected during a couple of months to a nearly vertical sun, the ice in those latitudes would be liberated, and would be floated by the earth's rotation down towards the equator. Thus a whole fleet would be sent annually from the poles. In Venus the arctic circle reaches to within about fifteen degrees of the equator; and therefore nearly all localities, to the north of this, would be covered with drift and water-worn materials each year.

Thus, whatever other local circumstances may affect Venus, still the sudden change from a vertical sun to no sun at all, must produce these alternations of climate, and probably that planet may be now passing through her *glacial epoch.*

An examination of the mountains in Venus leads to the conclusion that they are much higher than any at present on earth. It appears that they in some instances are as much as a hundred and forty-four thousand feet above the ground around them. Thus these mountains

are twenty-seven miles in height, while those upon earth do not exceed five miles. It is not improbable, however, that the great change of climate which we have spoken of as occurring on Venus, may, in thousands of years, so rend and crack the elevated rocks as to produce greater uniformity of surface. At present, however, her mountains are enormous.

It has long been a question whether Venus possesses a satellite. It was stated by some of the earlier continental astronomers that they had distinctly seen one attending her; and some even went so far as to give the period of revolution of the supposed satellite. Modern observers, however, have not admitted the truth of these statements. This is a subject well suited to the inquiry of amateurs; for a good eye, a good telescope, and a little perseverance are all the requisites for investigation. As far as the matter has gone, the evidence is decidedly in favour of Venus having an attendant; which may, however, be liable to great variations in brightness, just as are the satellites of Jupiter.

Not only as regards her proximity and phases, but for many other reasons, our nearest neighbour Venus is an object of interest, and is well worthy of telescopic investigation.

CHAPTER VI.

JUPITER.

Almost rivalling Venus in brilliancy and apparent size, Jupiter is the next object to which we shall direct our attention. This planet shines with a pale light, and is at all times remarkably brilliant, but most so when he is in the south at midnight, because then he is nearest to the earth. Jupiter is by far the largest planet in the system, and exceeds the earth in size as much as the egg of an ostrich exceeds that of a sparrow; he being nearly ninety thousand miles in diameter, whilst the earth is less than eight thousand. His distance from the sun is very great, and his year a long one; the first being four hundred and eighty-five millions of miles, and the latter nearly twelve of our years. Thus Jupiter can never be

nearer to the earth than about four hundred million miles.

Jupiter. The Earth.

The receptability of light of this planet must be very great, for he appears nearly, if not quite, as bright to us as does Venus; yet the one throws his *reflected* light four hundred million miles and the other only about sixty million, and Jupiter is more than seven times as far from the sun as is Venus.

Jupiter may be seen at any time of night, in consequence of his orbit, or course, being outside that of the earth. From his large size and great brilliancy he is not likely to be mistaken for any other planet or star, unless it be the Dog-Star, called also Sirius; but as the position of Sirius will be pointed out at a future page, even this mistake ought not to occur.

However much we may be accustomed to deal with figures, we still fail to realize the great distances of the celestial bodies, and hence the vastness of the universe, unless we are more forcibly reminded of these distances by some comparison with terrestrial objects. Thus we may better comprehend the distance of Jupiter from the earth, when we find that if an express train, travelling continually, started from the earth towards Jupiter when he was at the shortest distance from us, it would occupy more than nine hundred years to reach him, although it travelled at the rate of fifty miles an hour.

Jupiter will always be visible during nearly

nine months in the year, the period when he is invisible is when he is behind the sun. When first observed as a morning star he is not very brilliant, nor does he appear so large as he will when he is a midnight star.

If when Jupiter is first observed as a morning star, we notice the stars which appear to be close to him, we shall find that each morning he will when he rises be a little more to the east of these stars; that is, he will appear to have moved to the left of the stars near him. This change in his apparent position will continue for several days, after which he will gradually slacken the rate of his movement, and will then not appear to change his place amongst the fixed stars. After remaining stationary during two or three days, he will then appear to move in the contrary direction, that is to the right, and he will continue this motion for some months. He will then become stationary, and will again move to the left.

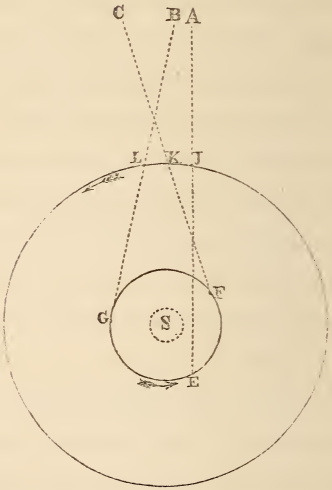
These apparent changes of position, in a

remarkable celestial body such as Jupiter, caused the ancients to direct their attention particularly to these "wanderers," as they called the planets. The movements of the planets appeared to them, however, hopelessly intricate; and probably even to modern observers, who have never devoted any great attention to the details of the celestial worlds, the above explanation may appear to indicate that intricacy is one paramount obstacle to thoroughly understanding the motions of the different celestial bodies.

A little sketch may often do away with the apparent confusion of a description; and such, we believe, will be the result in the present case if the following diagram be examined.

The orbit of Jupiter is represented by the circle J K L; that of the earth by the circle E F G; the sun is shown at S, and three stars are represented at B A C. The earth we will suppose to be situated at E, and Jupiter at J. Jupiter would now appear from the earth close to the star A, which, however, is

infinitely farther off than is Jupiter, but the two would appear close together in the sky.



In about four months the earth would have moved to F, and Jupiter to K, whilst the fixed stars A B C would not have altered their positions.

When the earth was at F and Jupiter at K, he would appear close to the star C, and therefore he would seem to have moved, as regards the stars, to the left. In about three or four months from the last period, the earth would

have reached G, and Jupiter would be at L. Jupiter would now appear to have moved to the right of the star C, and to be close to the star B.

Thus we have first an apparent movement to the left; then Jupiter is stationary; then he appears to move to the right; then he is stationary again; and lastly, he seems to be moving to the left, when he is hidden by the sun's light.

All these apparent changes in position of this planet are due to the joint movement in the same direction round the sun of the earth and the planet.

When Jupiter, or any other planet, moves from the right towards the left, that is from west to east, his motion is said to be "*direct*," because this is the direction in which the sun appears to move amongst the stars during the year. When the planet travels in the opposite direction, its motion is said to be "*retrograde*."

Jupiter occupies a period of four thousand three hundred and thirty-two days to travel round the sun, and thus the Jovian year is

equal to eleven years and three months of our time. A Jovian gentleman, therefore, who was six years old ought to be thinking of retiring into private life, whilst a lad in the same planet, aged one year and a half, ought to be starting in some profession.

To circumnavigate the planet Jupiter it would be necessary to travel no less than two hundred and eighty thousand miles, a distance greater than twenty-two voyages to Australia.

Fontenelle, in his 'Plurality of Worlds,' describes very humorously the supposed conditions upon Jupiter. The countess says, "'Pray tell me, if the earth be so little in comparison of Jupiter, whether his inhabitants do discover us?' 'Indeed I believe not,' says I; 'for if we appear to him ninety times less than he appears to us, judge you if there appears any possibility; yet this we may reasonably conjecture, that there are astronomers in Jupiter, who, after they have made most curious telescopes, and taken the clearest nights for their observations, may have discovered a little planet in the

heavens, which they never saw before: if they publish their discovery, most people know not what they mean, or laugh at them for fools; nay, the philosophers themselves will not believe them, for fear of destroying their own opinions. Yet some few may be a little curious; they continue their observations, discover the little planet again, and are now assured it is no vision; then they conclude it has a motion round the sun, and after a thousand observations, find that it completes this motion in a year; and at last (thanks to the learned) they know in Jupiter that our earth is a world; everybody runs to see it at the end of a telescope, though so little that it is scarcely discoverable.'

"'It must be pleasant,' says she, 'to see the astronomers of both planets levelling their tubes at one another, and mutually asking what world is that? What people inhabit it?' 'Not so fast either,' replied I; 'for though they may from Jupiter discover our earth, yet they may not know us; that is, they may not in the least suspect it is inhabited; and should any one

there chance to have such a fancy, he might be sufficiently ridiculed, if not prosecuted for it.'"

If we were to trace a line in the heavens where the sun each year moves amongst the fixed stars, we should find that Jupiter is never very far from this line. He is at times just a little above, and at others equally below this line; his greatest variation from it being rather more than twice the apparent diameter of the sun.

Upon directing a telescope of even moderate powers towards Jupiter, he at once loses the star-like appearance which he exhibits when seen with the naked eye, and shows a round bright disc. Immediately in his neighbourhood there will be seen four, or fewer, little bright bodies, which exhibit a constant light, differing slightly from that of a star. If these bodies be looked at occasionally during an hour or so, they will be found to have altered their relative positions as regards the planet and themselves.

When a telescope is used with a high magni-

fying power, Jupiter appears nearly as large as does the moon; and the satellites, as the small attendant bodies prove to be, also show a diameter, and other interesting phenomena. We will first speak of the planet as he is seen by the aid of a powerful telescope, and secondly, of the satellites.

One of the first facts connected with Jupiter, and revealed by the telescope, is, that like the earth, he turns upon his axis, and thus possesses a day and night. An examination of several spots upon his surface shows that the rate at which this large planet turns round exceeds by far that of the earth. The duration of the Jovian day and night is about nine hours and fifty-six minutes; and thus these periods of light and darkness are nearly "watch and watch about," as on board ship.

In consequence of the shortness of the Jovian day and night, there are upwards of ten thousand four hundred days in each year, and the various bodies on his equator are carried over a space of upwards of twenty-eight thousand miles per hour.

It is supposed that if the earth were to spin round with a velocity equal to the above, the various objects on the surface would be sent flying into space; such an assumption, however, is only a guess, and it is probable that the same force which causes this rapid rotation on Jupiter also causes other conditions which keep matters in order.

Some amusing speculations have been made as to the supposed height which a cat might jump upon the surface of Jupiter, in consequence of this rapid rotation: of course by the aid of a few preliminary but important suppositions, it can be proved that the leap of the cat would be enormous. So also might we find on earth, by certain theories, how much higher we ought to jump at the equator than at the northern regions; and thus the crafty foxhunter, by occupying the more equatorial portion of the field, might overcome obstacles which would effectually "pound" his less scientific friends. As conjectures these theories are amusing, but as facts they are not very

valuable, for we know not as yet the causes of gravity, of a planet's rotation, nor of any of those effects which bear upon the question; and hence we cannot venture to predict the result which might occur by an assumed change of conditions; for we are but upon the surface of a law, where we see its effects only, but know not the successions of effects which intervene between the great First Cause and that which our senses enable us to comprehend.

The various marks upon Jupiter afford a means whereby the changes in his seasons can be known. These changes are very slight; and thus a singular difference exists between the climatology of this planet and that of Venus. The Jovian world has scarcely any change of season, provided that the variation in the sun's altitude is the only cause of change; for the difference between the summer and winter altitude of the sun is less than seven degrees, whereas on our earth this difference amounts to nearly forty-seven degrees. The equatorial regions of Jupiter must therefore be much

hotter than regions either to the north or south, whilst his polar regions are either eternally frozen, or upon the verge of a frost. There may be, and probably are, conditions upon that planet which fit it for the residence of beings possessed of senses perhaps higher than those on this world.

It would appear to follow as natural, that the central portion of Jupiter should appear much brighter, than either the northern or southern regions, for the first locality receives the vertical, whilst the other receives the oblique rays of the sun. This conclusion agrees with observation, which indicates a brightness in the central portions nearly double that of the extreme northern and southern regions.

In addition to the spots which serve to indicate the rate of rotation, there also exist on Jupiter several singular dark and light streaks, called "*belts*." These belts are all parallel to each other, and run across the planet in the same direction as his equator; that is, they all lie across him from east to west.

There have been instances recorded when there were no belts seem upon Jupiter, and yet at the same time clouds were visible in his atmosphere. Thus the belts change their appearance, or vanish. They also seem at times to be brighter than the surface of Jupiter, or darker, according to circumstances. There is usually seen a bright central belt, bordered by two darker lines; but it is singular that these do not appear to extend quite to the margin of the planet.

What these belts are is a matter of conjecture. It has been suggested that they are the effects of strong trade winds, or of long tracks of fluid somewhat similar to water; but nothing satisfactory is yet known, and the belts of Jupiter remain subjects for speculation and observation.

Of late years attention has been drawn to several bright spots upon Jupiter. During the years 1850 and 1857 some notice was taken of this phenomenon, and considerable interest has been excited thereby. Like the belts, how-

ever, these spots are mysterious, and they may serve to remind us how little we yet know of the laws which govern the universe and produce changes in the various worlds; for not only are the spots on the sun mysteries, but the rapid rotation of Jupiter, his belts and bright spots, the ring of Saturn, and the purpose for which comets come, and a host of other phenomena, remain for future generations to explain. We may boast of being able to foretell for an immense period the time when an eclipse will happen, but we cannot predict the state of weather for even a week, and scarcely for twelve hours: yet as far as the convenience and benefit of society is concerned, the latter is the more likely to be practically useful. When we look back, and consider the advance which has been made in science within a few centuries, we may even hope that the state of weather will eventually be predicted, with at least some foundation upon truth; and perhaps, when the means of prediction have been discovered, we shall stand and wonder, lost in

amazement how such a simple law was so long overlooked by our predecessors.

During the autumn of 1857, when observing Jupiter with a telescope of moderate power, I noticed a singular appearance both above and below his poles. From the extremities of the axis there were two streams of bright light, in appearance like the tail of a comet, diverging as they receded from the planet, and plainly visible to a distance of ten diameters in both directions. The light appeared to vary in brightness and extent, and the phenomenon was very like an aurora. I first supposed that this appearance was due to some defect in the object glass, but having elevated the telescope so as to be well clear of the light of Jupiter, I used the slow-motion screw to move the axis of the telescope across the observed light. Having performed this operation several times, and finding exactly the same appearance, I concluded that the phenomenon was connected with the planet Jupiter.

and not with the telescope. Fortunately two friends came the same evening to the observatory, and upon looking through the telescope at Jupiter, they observed the same appearance; although when we directed the instrument to a star of the first magnitude, no such effect was visible. The night was one of the clearest and best suited for observation that I have ever seen.

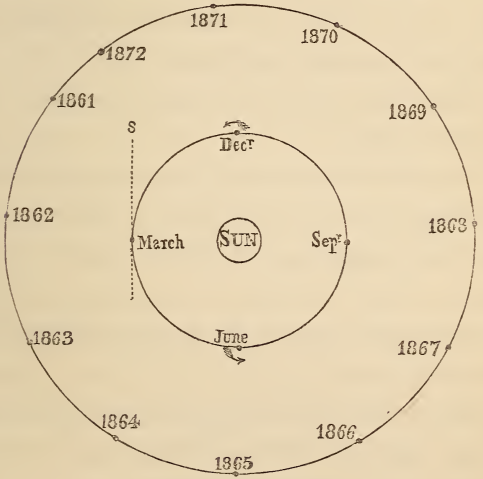
A few nights after, the atmosphere was again suitable for delicate observations, and Jupiter was re-examined. Instead of perceiving the aurora-like lights from the poles, there now appeared a much more feeble, but still a similar light on each side of the equator, and consequently at right angles to the former. These appearances are sufficiently remarkable to be recorded.

It may be a question for consideration whether a very brilliant aurora on earth might not be seen, if there were an observer with a good telescope upon Mercury or Venus;

and the phenomenon observed upon Jupiter bore a strong resemblance to this terrestrial paradox.

How to find Jupiter until 1872.

December, March, June and September, show the positions of the earth at these periods;



Jupiter's Positions until 1872.

the dates 1861, 1862, etc., show the positions of Jupiter at those dates. Remember that the

sun is south at noon, and that the earth turns round as shown by the small arrows. Jupiter's position may then be found at any time and season.

In June 1861 the sun will be south at noon, and Jupiter (see 1861, fig.) will be south shortly after the sun. Thus Jupiter follows the sun, and will be visible for a short period above the horizon just where the sun has set.

Where will Jupiter be seen at 6 o'clock P.M. in March 1862?

The sun being south at noon, then at 6 P.M. in March the south would be in the direction S, therefore Jupiter (see 1862) would be in the east.

Where will Jupiter be in September, 1869, at midnight?

The sun being south at noon, the south will be in the direction 1868 at midnight, and Jupiter will be seen to the east of south.

In April, 1869, Jupiter would be invisible, because behind the sun.

In December 1870, at 11 P.M., Jupiter would be seen to the south.

Thus, by remembering that east is to the left of south, west to the right, and that the celestial bodies move from east to west each night, we may always know whether Jupiter will become visible during the night, or where he is to be seen at any hour.

Jupiter is attended by four moons, which are from two to three thousand miles in diameter; the satellite next but one to the planet being the smallest, and the third satellite being the largest. Like the rotation of Jupiter, the revolution of these moons is very rapid; the first satellite, although at a distance of two hundred and sixty thousand miles from Jupiter, yet revolves round him in about forty-two and a half hours. The most distant satellite revolves round Jupiter in less than seventeen days, although it is more than a million miles from him.

These satellites move round Jupiter; and

appear from his surface to trace in the heavens almost the same course that is passed over by the sun during a Jovian year. Thus during each revolution of the satellites they will eclipse the sun, and will also be eclipsed themselves. The fourth, or most distant satellite, is the only one which at times passes round Jupiter without eclipsing the sun, or being itself eclipsed by him. In consequence of the rapid revolution of these moons, and the position of the orbit in which they move, the inhabitants of Jupiter will witness upwards of eight thousand eclipses during their year.

It is quite possible for the four moons to be visible at the same time in the heavens from Jupiter during the night. The first satellite would appear about the same size that our moon appears to us: the others would not be such prominent objects; still they ought to appear larger than any celestial object which we can see except the moon. The rapid and variable rate of movement of these moons

must afford the Jovian astronomers ample opportunities for finding their longitude; and the eclipses of the sun and of the satellites must enable them to keep their lunar tables in order, supposing that they have not yet discovered the *cause* of a planet's movements, or that they are independent of observations.

The eclipses of Jupiter's satellites, their shadows passing over his surface, they themselves being hidden, or "occulted" as it is called, by him, and their passage across his surface, afford the means of finding the time shown by a clock at Greenwich, although an individual may be in any part of the world.

In a publication called the 'Nautical Almanac,'* and at about the 500th page, the date and time of the various phenomena are recorded. These calculations are made for two years in advance, so that a traveller may take this publication with him to any part of the world.

* Price 2*s.* 6*d.*

The following is the tabular arrangement adopted in the work referred to :—

FEBRUARY.

	d.	h.	m.	s.
I. Oc. D.	1	21	23	
I. Ec. R.	2	0	53	18·5
I. Tr. I.		18	36	
II. Oc. D.		18	44	
III. Oc. D.		19	32	
I. Sh. I.		19	56	
I. Tr. E.		20	49	
II. Oc. R.		21	20	

*** The abbreviations denote as follows :—Ec. Eclipse. Oc. Occultation. Tr. Transit of Satellite. Sh. Transit of Shadow. D. Disappearance. R. Reappearance. I. Ingress. E. Egress.

The year is of course indicated upon the back of the publication; the month is shown as above, "February." The I. Oc. D. means that the 1st satellite is occulted and disappears behind Jupiter. The time of this occurrence is indicated by the 1 d. 21 hrs. 23 min.; that is, at 21 hours 23 minutes past the midday of the

1st of February, Greenwich time, the first satellite would disappear. The most convenient time for observing these phenomena is when Jupiter is found in the south at midnight, because then he is nearest to the earth. The time of an eclipse or occultation would then be about 12 hours after noon, and indicated thus: 1 d. 12 h. 0 m. 0 s.; that is, the first day a phenomenon would occur at 12, midnight.

It is of the greatest use to be able to tell the Greenwich time when at different parts of the world; and it is even interesting in out-of-the-way country places to be able to set our clocks by the aid of a satellite, distant from us at least four hundred million miles.

The four moons of Jupiter would appear a most singular and interesting sight to a terrestrial astronomer, as they rapidly traversed the sky of the Jovian world. Our one moon, when full, is a glorious object, especially when viewed through the transparent medium of a tropical atmosphere. But the sight of sights must be

the planet Jupiter seen from his first satellite. From this satellite the planet Jupiter could be seen to exhibit phases similar to those of our moon. Instead, however, of appearing a small body, like our satellite, Jupiter would appear a huge sphere, measuring in diameter more than *thirty-eight* times the diameter of our moon. Such a splendid body must, we should conceive, when illuminated by the sun, cause the reflected light cast upon the satellites to be nearly equal to the sunlight. Our telescopes, however, do not clearly show that the side of the satellites nearest to Jupiter is much brighter than the side away from him, although in the first case there is the joint light of the sun and Jupiter, whilst in the second case there is the sunlight only. Thus it is evident that in spite of the distance of the sun, its means of lighting the various worlds are such that Jupiter and his satellites are as brilliant as any bodies in the system; and hence we are led to the conclusion that there are numerous other conditions affecting the amount of light which a

planet obtains besides merely its mean distance from the sun.

The Jovian satellites are subject to great variations in brightness, and in their apparent size. The third satellite is that which is almost always the brightest; but from observations made in the year 1707, this satellite was found to have so much decreased in brilliancy, that its light was less prominent than that of the three other moons. It has been supposed that there are spots upon the satellites, and that these spots vary in extent; hence the brightness of the different moons would vary inversely as the size of the spots.

There appears to be but little doubt that the satellites of Jupiter are surrounded by an atmosphere. M. Cassini in 1678 remarked that he could not perceive the shadow of the first satellite as it passed across the surface of Jupiter, although the spots upon it were clearly visible. Hence he concluded that the satellite was surrounded by an atmosphere which possessed considerable refractive power, which thus

caused the sun's rays to bend round, and to decrease, if not entirely to do away with, the satellite's shadow. If this supposition be correct, and these satellites do possess an independent atmosphere, it would appear that they are in a more advanced condition than our moon; and thus the planet Jupiter, with its attendants, may be a young solar system, the secondary members of which are passing through their great geological periods, obedient to a prearranged law, which shall fit them to support their various phases of vegetable and animal life, and at last to receive upon their surface the image of the Creator.

The colour of the satellites is found to differ, although they shine merely by reflected light. Sir W. Herschel states that he found that the first satellite had a whitish tinge; that the second possessed a bluish white, which varied slightly. The third was always white, whilst the fourth was of an orange-red colour. Later observers consider that the fourth satellite is of a bluish, and the third of a yellowish colour, whilst

that of the first and second inclines towards blue.

A somewhat unphilosophical system has of late years crept into that which may be called exact science: this is, to assume that all the ancient recorded observations which do not agree with the modern must have been incorrect. There is not the smallest reason to conclude that there are no changes going on in the universe; in fact, the whole history of the earth, geological and astronomical, gives direct evidence to the contrary. Geology especially teaches us that our planet has passed through a succession of long epochs, each of which differed in conditions from its predecessor; and thus that change is one of the laws which has been ordained by the great Architect of space, and of the worlds rolling grandly therein. When it is asserted that ancient observations must have been incorrect *because* they differ from those of the moderns, we must premise that no changes have occurred, or are occurring, in those bodies which have been ex-

amined: and how can we know this? We can merely guess that there is no change; but our guess may be wrong. If, however, we reject recorded facts simply because they disagree with that which we at present see around us, we are putting aside those sound principles of investigation and deduction, which have led to some of the most important discoveries of modern times.

The satellites of Jupiter may be undergoing most important changes, which may cause their light to vary in colour and intensity. In the days of Sir W. Herschel they reflected light of one colour, now they may reflect another coloured light. It is these small changes, extending over long periods, which will probably, if fairly examined, enable us with our advancing collateral knowledge to grasp the key which will unlock some of those problems that have hitherto defied solution. But to deny facts simply because they may differ from that which we now see, is a proceeding which, if generally adopted, would enable us to

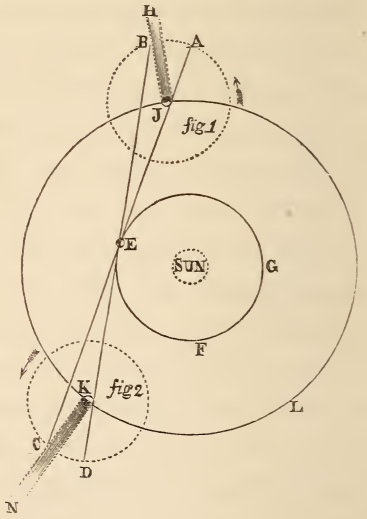
demonstrate that England had never been without railways or steamers, because we had always seen her furnished with both.

If the disappearances and reappearances of Jupiter's satellites be observed, it will be found that at certain periods the satellites will pass from the western side to behind Jupiter, and will, until they seem to touch him, continue bright. Instead of reappearing upon his eastern side, and being seen bright and distinct as before they disappeared, they will not become visible until they are at some distance from him. Then at another period the satellites would move up towards Jupiter as before; but they would not in their approach continue bright, but would disappear before they reached him. When they thus disappeared, they would reappear on the eastern side quite bright.

These changes are due to the position of the shadow of Jupiter and the place of the earth, and they may be easily understood by an examination of the following diagram :—

Suppose S the position of the sun, E F G the

earth's orbit, J K L the orbit of Jupiter; the small circles round Jupiter are the course of his satellites. If the earth were at E and



Jupiter at J, Jupiter's shadow would be thrown in the direction J H. As the satellite moved around him, in the direction shown by the arrow, and reached the point A, it would then be lost sight of from the earth at E, because it would have moved behind Jupiter; the sun,

however, would have shone upon it as it disappeared, and therefore it would have been bright as it passed behind Jupiter. This same satellite would not reappear until it had cleared Jupiter's shadow, and had arrived at B: thus it would first become visible at some little distance from Jupiter, and upon the left-hand side.

We find Jupiter at K (fig. 2), and the shadow thrown in the direction K N. The satellite moving around Jupiter as before would now disappear when it entered his shadow at C. This satellite would be at a considerable distance from Jupiter when it was thus lost sight of, as will be evident by noticing how far the line E C is from Jupiter, for this line represents the line of sight from the earth to the satellite. This same satellite would be again seen from the earth when it reached the point D; it would have been shone upon by the sun before it became visible, and therefore it would be seen to emerge from Jupiter quite bright.

Thus in the second instance the satellite disappears before it reaches Jupiter, and reappears

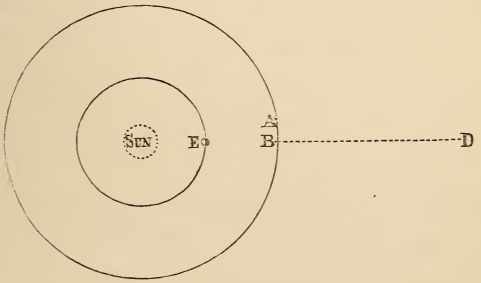
close to him. In the first instance it disappears close to him, and reappears at some distance from him.

In consequence of the satellites having in some instances to pass behind Jupiter, and to move also through his shadow, they will be invisible during a longer period than when Jupiter and his shadow appear as one when seen from the earth. When the shadow is behind Jupiter, the sun, earth, and Jupiter must be in a straight line, and at this period Jupiter passes to the south of all terrestrial localities at midnight. At this period his nearest satellite is invisible for about two hours and fourteen minutes; but when the same satellite is observed, and Jupiter and his shadow do not appear as one, then this same satellite will be invisible for about three hours and a half.

The eclipses of the satellites of Jupiter have served to reveal a very interesting law of nature—viz., that light requires a certain time to travel over space, or through that subtle

medium which exists between the various worlds in the universe. That there was a high probability that the velocity of light was not infinite was suggested as early as the time of Francis Bacon. It was not, however, until a much more recent period that the matter was definitely settled, although it is like most other problems—very clear and simple *when we know it.*

To show how it is known that light occupies some time to traverse space, we will take a simple illustration:—



Suppose E the earth, and A the position of Jupiter and his satellites, and let us suppose that B is another planet with satellites close to

Jupiter, and at exactly the same distance from the earth. Now let the nearest satellite of these two planets revolve at exactly the same rate, let the eclipses and occultations occur at exactly the same instant, and in fact let the two bodies A and B be exact counterparts of each other.

When the satellite was eclipsed at A, at that same instant would the satellite be eclipsed at B, the two phenomena occurring at the same time.

Now let us suppose that the planet B and its satellite moved slowly away from the earth, and in the direction of D, the actual rate of the satellite's movements and the period of its eclipses being the same as before.

If we now found that the eclipses of the two satellites at A and D appeared to occur simultaneously, it would show that the velocity of light was infinite; if, however, we saw that the satellite at A appeared to be eclipsed *before* that at D, it would indicate that light occupied some time to pass from D to A. If we knew

the distance A D, and the difference of time between the eclipse at A and at D, we at once know the velocity of light. For instance, if A D were one million miles, and the difference in time of the eclipses one minute, then one million miles per minute would be the rate of light. The true velocity is much greater than this, being nearly twelve million miles a minute.

As an additional example to illustrate the fact of the velocity of light, let us suppose that when the two satellites were eclipsed at A and B, a gun was fired from each planet A and B, the report of these guns would reach E at the same instant. Then the same event occurring we should find that as B moved away from E towards D the report of the gun fired from D would arrive after the report of the gun fired from A, and thus the velocity of sound could be ascertained. Let us substitute a ray of light for the wave of sound, and we have exactly the same result.

The distance of Jupiter from the earth varies

considerably; he is nearest when he passes the south at midnight, and is farthest when near the sun in the heavens; and thus, by the variation in his distance from the earth and the number of his eclipses in a given time, a means is found to indicate the velocity of light.

MARS.

Vincent Brooks, lith.

Spots on Mars and white patches at the poles, probably snow.

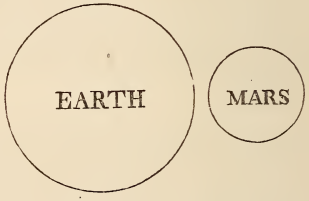
CHAPTER VII.

MARS.

A LARGE bright-red looking object in the sky, which does not scintillate like a star, and which is visible in a portion of the heavens different from that in which the sun has set, is most likely to be MARS. In consequence of this planet lying farther from the sun than the earth, it is visible in all parts of the heavens, and is thus unlike Venus in its motion. He will appear larger and brighter when due south at midnight than at any other time, because then he is much nearer to the earth. Mars approaches the earth more closely than any other planet except Venus, as he is distant about fifty million miles when he is nearest to us: thus an express train, travelling at an uniform rate of fifty miles an hour, would

pass over the shortest distance which separates Mars from the earth in about one hundred and twenty years.

Mars is a very small planet, his diameter being rather less than four thousand miles, although from his proximity to us he is often a very remarkable object in the heavens. Placed beside the earth the relative dimensions would appear as below:—



We have mentioned that Venus always exhibits phases, like the moon, and is never visible when fully illuminated, whilst Jupiter invariably appears round and bright. Mars, however, can at times be seen when the whole surface is not visibly lighted by the sun, and then his appearance is like that of the moon when within a few days of the "full." The *phases* of Mars are visible to us, because we

obtain a side view of the planet when he is nearly in the same part of the heavens as is the sun; whereas, owing to the distance of Jupiter, we cannot see any part of his surface that is not illuminated. As early as the year 1610, Galileo perceived that Mars was not at times perfectly round.

The year of Mars, being one terrestrial year ten months and two days in length, is nearly as long as our own.

When a telescope of moderate power is directed towards Mars, several spots are observed upon his surface: many of these are permanent, and quite distinct. They appear in groups and of various shapes, the greater quantity being situated in northern regions. Upon the same principle that we were able to tell that Jupiter rotated upon an axis, we also know that Mars partakes of this almost universal movement. Thus the day and night alternate upon this planet, the period from the noon of one day to that of the next being about twenty-four hours and thirty-seven minutes.

Thus his day and night do not vary much from the length of our own.

The spots upon his surface also show that the annual alternations of climate are not very different from those on earth; the variation in altitude between the midsummer and mid-winter sun being about fifty-seven degrees, whilst on our world it is forty-seven degrees. There is not, therefore, the great alternation of cold and heat which occurs upon Venus, nor the uniformity of climate which exists upon the surface of Jupiter. Amongst the various interesting facts which the telescope has revealed, not the least is that of the rotation of the planets in our system upon their various axes, in such a manner that they all have either a slight or great variation of season, and thus that summer and winter alternate upon the surface of each world. That there is every reason to conclude that change of season is experienced on Mars may be shown by the circumstance that around his poles during their winter season appear brilliant white

spots, which have fairly been looked upon as accumulations of snow. The spot around the north pole increases in size as the northern winter approaches, and is largest at mid-winter. When the spring and summer approach, the white gradually diminishes, until at midsummer it is scarcely visible around the north pole. Thus, when each hemisphere is in winter, the white spots around the pole become apparent; then when the summer approaches, the spot disappears. These white spots appear more than double as brilliant as any other portion of the surface of Mars; and as they merely extend to about the same distance from the poles of Mars that our arctic and antarctic snows reach from our poles, it is reasonable to conclude that the climate of this red planet is not very different from that of our own. It has been found that during the winter of Mars the snow extends to about thirty-five degrees from that pole which is in winter, but in the summer the snow is not more than six or seven degrees from the same pole. This is really

that which we should expect from the alternation in altitude of the sun between winter and summer; for in summer he would rise at midday about five degrees higher than our sun rises to us, and in midwinter he would be at a less altitude at midday than our sun, by the same quantity. Thus the *arctic circle* would in Mars extend to about twenty-eight degrees and a half, whilst our arctic circle reaches only to twenty-three degrees and a half from the poles.

It is indeed a singular fact that we can thus gaze upon another world, can observe the changes of climate upon his surface, and we may thus keep a register of his severe and mild winters. To even have hinted at such unheard-of wonders a thousand years ago would have aroused the ridicule of many an empty-headed critic, as would also the idea of much which we now have realized. Who shall venture to declare that in future ages a means of communication may not be discovered between other worlds and our own, perhaps by the aid

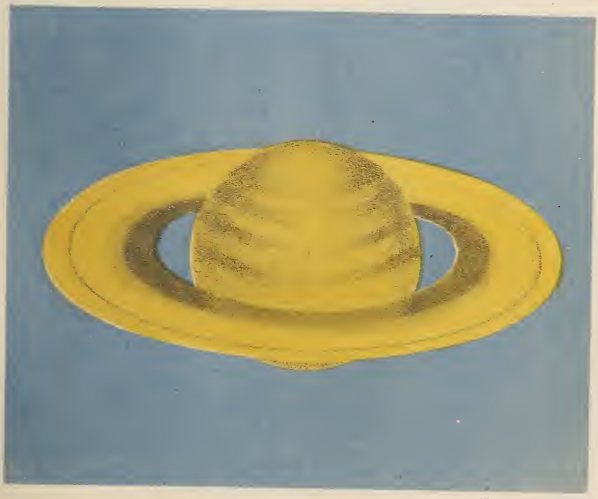
of forces as far beyond the subtlety of our present electrical force, as the delicacy of this communicating agent is beyond that of the few methods of telegraphing, or signalling, known to the philosophers of the early ages! It was once supposed impossible to make a signal beyond the limits of material terrestrial vision; now, however, it is supposed that where we can establish the material conductor there only can we telegraph, for it is necessary to lay the wire by which to speak. Who knows, however, what the future may reveal, and how much yet remains for unborn generations to glean!

CHAPTER VIII.

SATURN.

We have now to describe a world which presents peculiarities not in accordance with those which characterize any other member of the solar system, with which we are acquainted. Although not a very brilliant object in the heavens when examined with the unaided eye, still when the telescope is used, Saturn becomes a most interesting sight. Nearly spherical in form, like the other planets and worlds, Saturn is furnished with an appendage, the purpose of which is not known. Extending around him there is a sort of brilliant hoop, which does not touch him in any part, but yet seems to be a material substance. In addition to this hoop, or "ring" as it is termed, there are at least eight moons attendant upon Saturn. His size

JUPITER
and
his Satellites.



Vincent Brooks lith.

SATURN
and
his Ring.

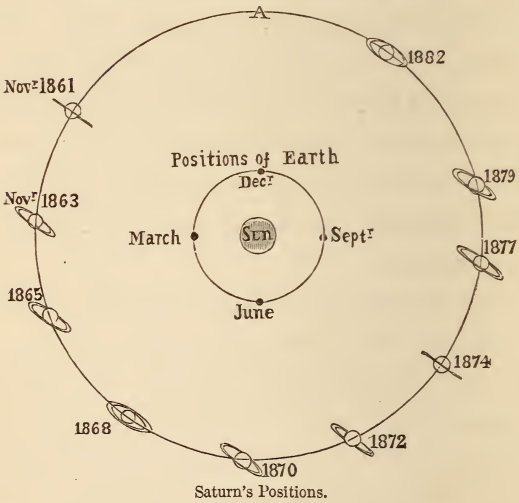
also is considerable, he being nearly seventy-six thousand miles in diameter: thus from his size, attendant ring, and numerous moons, he becomes a most important member of the solar system. Saturn, like Jupiter and Mars, may be seen in all parts of the heavens, for the planet is much farther from the sun than the earth is, which consequently may be between the two former bodies: thus Saturn may pass the south at midnight.

In consequence of Saturn appearing somewhat like a star, although he does not twinkle, it may aid the amateur to find him in the heavens, if we give a diagram, showing where Saturn is to be found during the next thirty years. No other knowledge will be required to enable the reader to comprehend the sketch, than to remember that the earth turns round during twenty-four hours, and that at noon the sun will be south.

In the centre of the accompanying diagram is the sun; four small spots round this show four positions of the earth during the year.

These four positions are marked December, March, June, and September. At twelve

How Saturn may be found until A.D. 1882.



Saturn's Positions.

o'clock (noon) the sun is due south; therefore, in December, at *midnight*, the south would be in the direction opposite to the sun; consequently A would be south at midnight.

In December, 1861, we should find Saturn nearly south-east at midnight, because A being south, Saturn is seen on the left.

In March, 1863, Saturn would be south about midnight; in June, 1870, also south at midnight.

As all the celestial bodies move from the east towards the south, we have merely to remember that they pass from east to south in six hours, consequently from south-east to south in three hours. Thus if a body is known to pass the south at midnight, it will be found in the south-east at nine P.M., the south-west at three A.M. Then suppose we wish to know where to find Saturn at nine P.M. in March, 1862. Nine P.M. would be half way between six P.M. and midnight, and therefore our south would point in that direction at that hour. We see on the sketch where Saturn would be in 1862. Thus, at nine P.M. in March, 1862, he would be a little to the left of south. An examination of this diagram will show where to find Saturn at all times of night and of the year, for the next thirty years.

Saturn is much farther from the sun than either Jupiter or Mars, and as a consequence

his year is a long one, consisting of twenty-nine of our years, five months, and sixteen days. A terrestrial mortal, therefore, if a resident upon Saturn, and yet subject to terrestrial conditions, would barely live long enough to see three summers; for if he died at the mature age of eighty earthly years, he would still merely be three years old, according to the years of Saturn.

In spite of the large size of this singular planet, still he rotates with great rapidity, his day and night consisting of only ten hours and twenty-four minutes. Thus a terrestrial day and night are longer than two of Saturn's; and therefore during a given period the sun rises and sets to the Saturnites more than twice as often as he does to the earth-dwellers.

The ring of Saturn also spins round, and with a velocity almost equal to that of the planet, as it rotates in about ten hours and forty minutes.

We have before mentioned that all the planets and satellites shine only in conse-

quence of being lighted by the sun; it is found, also, that this ring of Saturn is visible only from the same cause; for the shadow of the ring is distinctly visible upon the body of the planet, whereas if the former gave out light there would be scarcely any shadow. Also it is found that the planet casts a shadow on the ring, and thus it is known that the former shines at least mainly by reflected light.

We have spoken of *the* ring of Saturn, but the appendage referred to really consists of several concentric rings, which appear to be separated one from the other. The extreme diameter of the exterior ring is about one hundred and seventy-six thousand miles, and it extends to upwards of forty-eight thousand miles beyond the surface of the planet. The breadth of this exterior ring is about ten thousand five hundred miles, whilst its thickness is not more than two hundred and fifty miles. From this earth the ring of Saturn will not always appear of the same shape, because, owing to the movement of the planet around

the sun, and with an axis inclined from the perpendicular, we sometimes see the ring of an elliptical form, or as a straight line. In the diagram which we have given to show the position of Saturn during the next thirty years, we have also shown the relative position of the ring as it would appear from our earth. It will there be seen that in the year 1861 the ring will appear like a thin streak of light; whilst in the year 1868 it will be in its most open form, and therefore best suited for observation.

Conjectures have of course been made as to the formation of the ring of Saturn. One of the earlier astronomers of modern times * supposed that a number of satellites were strung together, and thus formed a continuous body. Another individual believed that Saturn was once much larger than he is now, and that the ring is a sort of remnant of the planet, and which has not shrivelled up like the remainder. Then it has been supposed that a comet was captured by the gravitating influence of Saturn, and the

* James Cassini.

comet's tail has now attached itself to the equatorial regions of the planet. In almost all the conjectures which have been made in connection with this body, there is one preliminary proposition which appears to have been assumed —viz., that the ring was not always an appendage of Saturn. We now know that the ring is not a number of satellites strung together, and we also perceive that it is far more solid than the tail of a comet; and thus two at least of the speculations are worthless, whilst the other mentioned is untenable from an absence of facts upon which to base it. Within the last few years it has been shown that several changes are occurring in Saturn's rings, a new ring having been found to separate itself from the others. This is a fact tolerably well ascertained; and it is an interesting one, inasmuch as it indicates that changes of some kind are occurring in at least one of the members of this system.

When the surface of Saturn is examined with high magnifying power, several streaks or

belts are observed, somewhat similar to those visible upon Jupiter: these belts do not run across the planet parallel to the rings, but they incline to and from them to the amount of several degrees.

The polar regions of the planet are found to vary considerably in brightness—a fact which seems to indicate the presence of an atmosphere, or of changes of temperature.

Saturn is attended by at least eight moons, or satellites, which revolve around him at different distances. The nearest moon to him is little more than half the distance from his surface that our moon is from us, and it moves around him in a period of about twenty-two hours thirty-seven minutes. Owing to the distance of this body, and the position of his ring, the eclipses of the satellites cannot be observed with such facility as those of Jupiter's moons; but to be able to perceive the eight moons of Saturn is a proof that the telescope with which we observe is a good one.

CHAPTER IX.

URANUS AND NEPTUNE.

Beyond the orbit of Saturn, and at a vast distance from the sun, there are two worlds which far exceed in size our own earth. One of these, Uranus, moves round the sun in about eighty-four of our years, and is distant upwards of eighteen hundred million miles from the sun. The other, Neptune, occupies nearly a hundred and sixty-five years to move round the sun, from which he is distant about two thousand eight hundred and seventy million miles.

From the great distance of these two planets they present very few peculiarities to the eye of the common observer; for unless examined with telescopes with very high magnifying powers, their diameters even will not become appreciable. Both these planets are attended with satellites, probably with many; eight, however, are usually assigned to Uranus, and

one or two to Neptune. We have mentioned that it appears to be a rule that the satellites attendant upon a planet invariably move round their primary in the same direction that the primary itself rotates. Thus the satellites of the earth, Jupiter, and Saturn move around from west to east—that is, from *right* to *left* if they were seen from the northern regions, but from *left* to *right* if seen from the southern.

If we observe the satellites of Jupiter from the northern hemisphere, we shall find that when they are moving from right to left they will pass behind the planet, but when moving from left to right they will pass across his disc. Thus if N S were the north and south poles of Jupiter, a satellite would revolve round him from A to B, when it would appear upon Jupiter's disc; it would then move on to C. Thus it would move from west to east round Jupiter.

If now we were to turn the axis N S down into a horizontal position, and still keep the satellite revolving round the equator of Jupiter,

we should see the satellite move thus—from A to B, C, and D (upper figure), or from *our* west over to our east, or thus—

from A to B, C, and D (lower figure); that is, from *our* east over to west, just as we turned the north or south pole towards us — hence these moons would move with left or right hand rotation, just as the *north* or *south* pole of Jupiter was turned towards us.

The satellites of Uranus appear in this manner, in consequence of the axis of the planet being turned down, as it were, horizontally, so that during forty-two years they

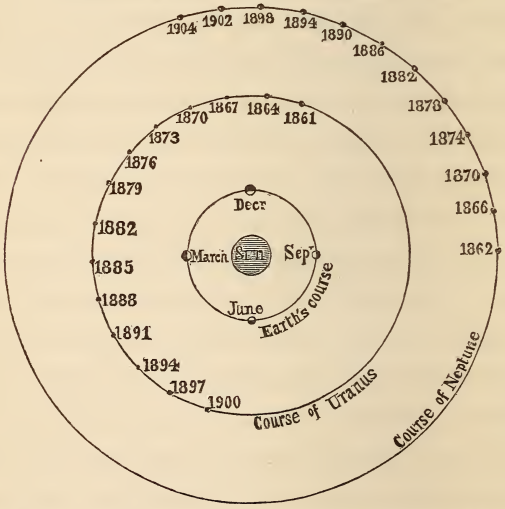
would appear to move from east to west, or *retrograde*, as it is termed; then for forty-two years they would appear to move from west to east, or *direct*.

Some slight confusion has been allowed to exist in connection with the movements of these bodies, some writers having gone so far as to state that their motion was at variance with that of all other satellites. The fact is, however, as shown above, a simple change in their apparent movements, according as the one or the other pole of Uranus is directed towards the earth; and as the same pole remains turned towards the earth for forty-two years, the fact of a change occurring was overlooked. We should not be warranted in asserting that the sun moved in opposition to the rules of the solar system when we observed him from the southern hemisphere, and when consequently he moves from right to left each day; neither ought we to state that the moons of Uranus move in an irregular manner, simply because sometimes they will be seen to move with right-

hand rotation, and after many years with left-hand, just as the north or south pole is turned towards the sun and earth. It cannot even be said that the position of the axis of Uranus is an unusual one, for we know not what is the most general position, no two planets being exactly alike. The inhabitants of Uranus might as well state that our earth's axis was in an excentric position, because the sun was never vertical at midday beyond twenty-three and a half degrees on each side of the equator, whereas to them he was sometimes vertical, even in polar regions. In fact, it is not philosophical to take our own tiny earth as a model of perfection, and to assume all other worlds either imperfect or in an excentric condition, simply because they are slightly different in some details. Each, probably, is admirably suited to its position and constitution, and may be where it now is, simply because, by a prearranged law, it has reached the locality to which its atoms at present bear an affinity, and where it will maintain the balance of the universe.

The diagrams below will show the relative positions of Uranus and Neptune during the next forty years, the rules for finding them being the same as those for finding Saturn and Jupiter. The ring next the earth is the orbit

How Uranus and Neptune may be found until A.D. 1900.



of Uranus, the exterior that of Neptune. Thus, referring to Uranus, we know that during May, June, and July, from 1861 to about 1876, he would not be visible because behind the sun.

During November, December, and January, however, of the same years he will pass the south at about midnight. About March, from 1883 to 1886, Uranus will be found to the south at midnight, whilst at the commencement of June, 1900, he will be south about midnight, and not visible in December or November.

Neptune will not be visible in February, March, or April, for the next ten or fifteen years; September and October being the two best months for examining this remote planet for the next twenty years.

Mercury.

At certain intervals of about one hundred and twenty days a small brilliant red-coloured body will be observed in close proximity to the sun. The body to which we refer is the planet Mercury, which is situated at a mean distance of about thirty-six million miles from the sun. Mercury, like Venus, will be seen sometimes as a morning and at other times as an evening star,

but it will never appear so far away from the sun as will Venus. Thus either immediately after sunrise, or before sunset, this planet must be looked for. This little planet, which it is supposed measures less than three thousand miles in diameter, rushes round the sun in a period of about eighty-eight days. Thus the year of Mercury is only about one-fourth the length of our own, and if we lived to be sixty years old on our earth, we should be about two hundred and sixty years of age, counting by the years of Mercury.

It is found that, like all the other planets in the system, Mercury rotates upon an axis, and occupies about twenty-four hours and five minutes in rotating. It is assumed that Mercury rotates in such a manner that the sun will be vertical each year at midday at all localities, except those within twenty degrees of the polar regions. Thus, in consequence of the quick return of the seasons, and the extension of the tropical regions, there would be but little time for ice to form upon any part of

Mercury, as the sun would be absent merely a few days even from the extreme northern regions; thus a very uniform climate ought to prevail in that planet, which, with the quick return of the seasons, would probably be very suitable to the rapid growth of vegetation, especially so of that type of vegetable found so abundantly in our coal-fields. If then Mercury possess a soil and an atmosphere at all analogous to those of our earth, we might suppose that the little planet was now engaged in *coaling*.

It has been supposed by some observers that there are very enormous mountains upon the surface of Mercury of a height sufficient to alter the shape of the crescent which this planet sometimes shows. Like many other delicate observations connected with science, some observers assert, whilst others as vigorously deny, that these excrescences exist.

Mercury is seen occasionally to pass across the disc of the sun, when it appears a round opaque body, attended by a sort of atmosphere.

The passage of a planet across the sun is called "a transit" across the sun's disc. During the next forty years six transits will occur; viz. in—

1868 . . .	Nov. 4.
1878 . . .	May 6.
1881 . . .	Nov. 7.
1891 . . .	May 9.
1894 . . .	Nov. 10.
1901 . . .	Nov. 4.

The planet will occupy about from four to six hours in passing across the sun's disc, and therefore can easily be distinguished from a spot in consequence of the rapidity of its motion—a spot appearing to scarcely change its position during a whole day.

CONSTELLATIONS.

Fig. 1

Fig. 2.

Fig. 3

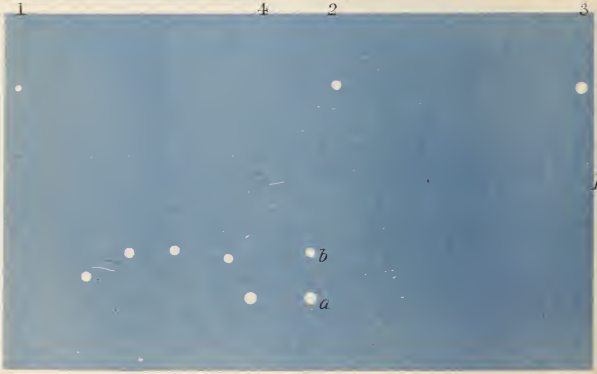


Fig. 4

Vincent Brooks lith

Fig. 1.

a.a. Betelgeux.
b.b. Orions belt.
c.c. Sirius.
d.d. Saiph.
e.e. Rigel
f.f. Bellatrix.
G.G. Aldebaran
h.h. Pleiades

Fig. 2.
Cassiopeia.

Fig. 3.
Northern Crown.

Fig. 4.

1.1. Vega or α Lyræ.
1.2. The Pole Star.
1.3. Capella.
4.4. The Great Bear.
a.b. The Pointers.

CHAPTER X.

THE FIXED STARS.

To the mere casual observer the stars appear to be scattered promiscuously in the heavens, and to have no special characteristics which can distinguish them from each other. A very little attention will, however, show that they differ in apparent size and brilliancy, that their colours vary, and that they are formed into groups or patterns which can, when once known, be easily recognized.

We have mentioned that some of the so-called stars are really planets similar to our earth, which would probably look like a small star if seen from one of them. These planets wander amongst the fixed stars, but around a particular course; and are therefore to be found at various periods near to various groups of stars. The fixed

stars, as the name implies, never move, or if they do, it is merely by the aid of delicate instruments and long examination that these movements become manifest. Hence a group of stars can always be recognized because the various members do not alter their relative positions.

If the stars be attentively observed for a year, it will be found that during summer very different constellations will be seen in various parts of the heavens to those which are visible in the same localities in winter. Some brilliant constellations, also, which we may observe during one season are invisible during another; other constellations likewise are *always* to be seen, but are found in different parts of the sky, according to the time of the year.

From the very earliest ages names have been given to the principal stars, and also to the constellations which are the most prominent in the heavens. Thus individuals are enabled to speak intelligibly in connection with the sky, just as we can with reference to various parts

of the earth; for if there were no such names as Africa, America, &c., the world would to us be a confused and indefinite accumulation of land and water, just as would the heavens if the stars could not be known by name.

If an individual acquainted with the names and positions of the various stars were to tell another who was ignorant of them that a comet or a meteor had been seen moving from Sirius towards Capella, the information would be about as interesting and instructive as though we told a Bushman that there was free trade with France. So far beyond the range of his knowledge would such an intimation be, that he would probably not trouble his mind about the matter. When, however, we know the direction or position thus pointed out, and also picture to ourselves the probable course of the comet, resulting from its movement in the direction indicated, and compare this course with that of others of which we have read, we begin to take an interest in the subject, simply because we understand something about

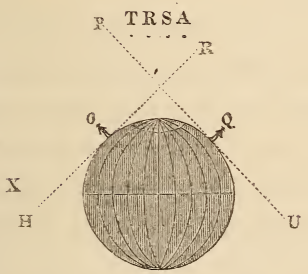
it. For it really appears as though individuals were not only indifferent to, but even often disliked some subject, simply because they were unacquainted even with its mere outline.

We will first endeavour to explain why it is that there are some stars which can always be seen in these latitudes; after which some of the principal constellations will be shown, and also their positions at various periods during the year.

A moment's reflection will show us that our view is bounded by the horizon; we cannot, therefore, see that which is below the horizon; all, however, that is above may be seen. Then let us remember that our earth turns round during about twenty-four hours, and we can understand the following sketch.

Suppose O the position of any person upon the earth, say, for example, in England, then the line H O R would represent the horizon of this person, and all that was above this horizon might be seen; therefore various bodies that were situated as T R S A P and X, would

all be visible from O. P would be nearly overhead, A near the horizon, and lower down than T.



In twelve hours' time, the same person would be carried by the rotation of the earth round to Q, when his horizon would be represented by the line P Q U. From the position Q, R would seem high above the horizon, and A much higher than T. P, which was nearly overhead when the person was at O, would now be just on the horizon, and X which was seen from O, would be invisible from Q.

Thus T R S A would be seen from both O and Q. The principal difference being, that at O, T was above A, but from Q, A was above T. This change would arise merely from the

fact, that the head of the observer pointed to a different direction at O from that in which it pointed at Q.

If T R S A are called stars, they would also be always visible from the positions O and Q, but X would be a star only visible from O.

The stars can only be seen during the night; and in consequence of the earth moving around the sun, night would occur on the side O or Q according to the time of year. When the night occurred on the side O, then the stars T R S A and X would be seen, T being above A. When the night happened on the side Q, X would not be visible, but T R S A would be seen, A being above T.

Hence there are some stars which are always visible during the night from certain localities, these stars being sometimes nearly overhead or close to the horizon, according to their position in the heavens and the time of year.

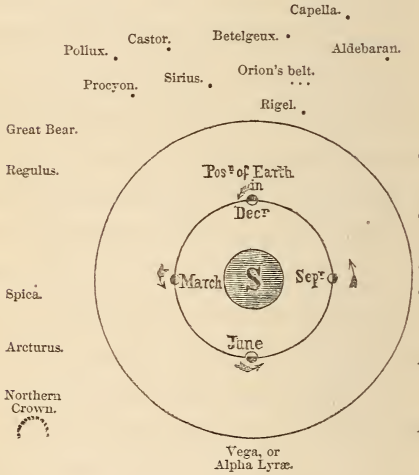
Among the stars which can always be seen from England, the following are the principal. The constellation of the Great Bear, also the

Pole-star and the Little Bear. The constellation Cassiopeia, the bright star Capella, called also Alpha Aurigæ, the bright star Alpha Lyræ, called also Vega, can just be seen on the horizon from the south of England when it is lowest, and to the north of us. At other times it will be found high up, and to the south. Alpha Cygni is another bright star always visible from England.

To enable any person to find the position of the various principal stars at any time of the year, the following sketch is given: the method to be adopted is similar to that for finding Saturn, Uranus, &c. Thus we have merely to remember that the sun is to our south at midday, to our north at midnight, and that the earth turns round in about twenty-four hours. When the sun is between the earth and a star, the latter is of course invisible, owing to the sunlight. By remembering these simple facts, the following sketch becomes intelligible.

The sun is shown in the centre of the diagram, the earth in four positions according to the time of year.

For illustration let us see which stars are to our south at midnight in December.



At noon, the sun is to our south, consequently twelve hours after noon, that is, at midnight, our south will be in the opposite direction. Thus Orion, Rigel, Betelgeux, &c. would be in the southern heavens at midnight in December. At about 9 P.M. at the same season, α Persei and Aldebaran would be nearly south. Stars in the direction of Vega could not be seen

because of the sun, unless they were near the northern pole of the heavens.

In September Alpha Cygni would be south about 9 P. M., Cassiopeia and Andromeda about midnight.

In June, we should not be able to see Sirius or Orion in consequence of the sun, whilst Capella would be in the north, and visible, because it is one of those stars always seen from England. Vega would be south at midnight at this period, and Altair at about one o'clock in the morning. Thus, by remembering in which direction the earth turns round, we can always find by this diagram the position of the principal groups of stars.

In March, at noon the sun is south; at 6 P.M. Orion, Sirius, and the stars near them; at 9 P.M. Regulus; at about midnight Spica; at about 3 A.M. Arcturus and the Northern crown; about 6 A.M. Vega and Altair. Also at midnight Sirius will be in the west, and setting, Vega in the east, and rising. A sketch of some of the principal groups of stars is shown in

Plate 8, so that they may be recognized by their forms.

In addition to the diagram which we have given, the position of the various stars may be ascertained by the aid of the constellation of the Great Bear and one or two other stars. The Great Bear is such a remarkable constellation that it can easily be found at any time; and hence the Pole-star can be found by the aid of the pointers. Then if a line be drawn from the Pole-star at right angles to a line from the pointers to the Pole-star, then this line will pass close to a bright star called Capella.

A line from Capella through the Pole-star will, if produced, pass through a bright star called Vega or Alpha Lyræ; thus Capella, Vega, and the Pole-star are in nearly the same straight line.

If a line be drawn from the Pole-star through the last star in the Great Bear, this line produced will pass through Arcturus, a bright reddish star, famous to all observers as the star

near which the brilliant comet of 1858 was seen when in its splendour.

The belt of Orion is another constellation easily recognized, hence Sirius becomes known (see Plate 8), also Betelgeux and Rigel. Then on the opposite side of the belt to that on which Sirius is found, and nearly in the same straight line, we find a star named Aldebaran.

Sirius, Betelgeux, and a bright star named Procyon, will form an almost equilateral triangle.

At about one-third of the distance from Arcturus to Vega we find a semicircular group of small stars, one of the group being large. This large star is named Alphacca, the group being the Northern Crown.

About midway between the Pole-star and the tail-star of the Great Bear, and nearly in the direction of a line joining these two, is the brightest star of the Little Bear.

A few minutes' attention directed to the heavens any evening will soon enable an individual to know some of the principal stars, and to find them, if visible, at any time of the

year. The principal groups of stars, such as the Great Bear, Orion, Capella, Cassiopeia, or the Northern Crown can be recognized by their form, some of the large solitary stars by their position relatively with the Great Bear and the Pole-star.

There is a vast field for speculation and admiration in the illuminated page spread before us during each clear night in the year. When we realize the fact that each twinkling star is a sun, the centre probably of a system of revolving worlds, each of which may be similar to that on which we dwell, we become bewildered amidst so much grandeur, and may well stand inspired with veneration and awe if we reflect upon our own insignificance compared with the extent of creation. When we behold these millions of suns glittering in the midnight heavens, we naturally ask, for what are they intended? It has been said that they are to give light on earth, and this is their most obvious use; but is it their only purpose? Have all these gigantic bodies, each of which is

ten thousand times the size of our pigmy world been created solely for the purpose of casting at rare intervals a dim light upon us. Such a conclusion would partake somewhat of the self-sufficiency of man, but would scarcely show that we realized the perfect system which has been adopted in creation, and the endless variety and originality which observation teaches us really exists.

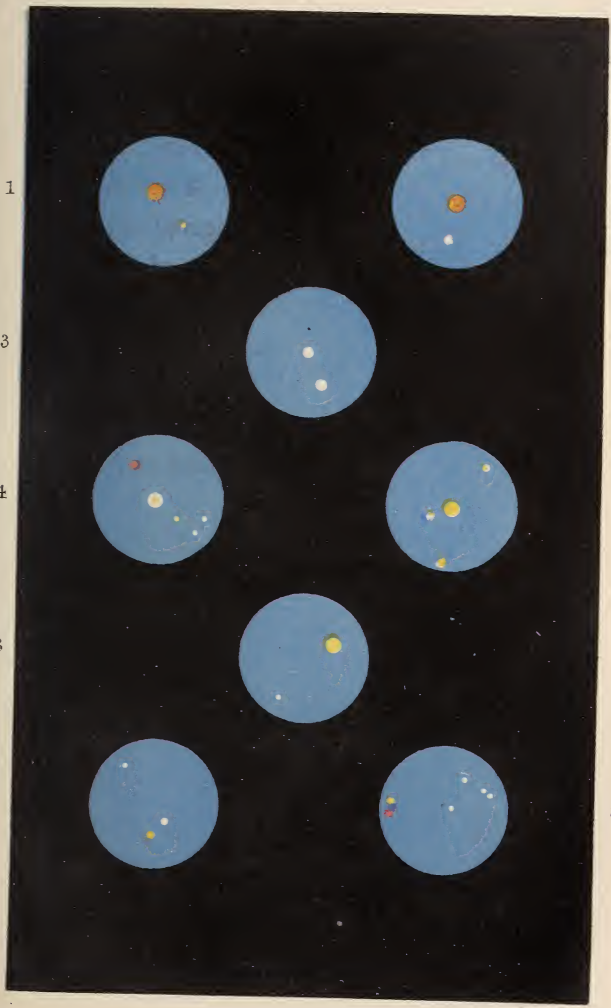
As far as we can judge from facts, it is supposed that the sun is a solitary member of our system, and that although attended by many planets or satellites, he is still without a companion. We cannot, however, say whether if our sun were seen from the Pole-star he would appear alone. It is probable that he would; and thus he presents a variation from other stars in the universe, some of which possess companions, which give out light and revolve round each other. Thus two suns belonging to one system would appear to indicate a higher or more advanced state, and at least to remind us that in creation there is an endless variety, both as

regards suns, systems, and worlds, or the most minute insects that creep around us.

Like most novelties, the early announcement of the fact that several of the stars were double, excited ignorant or bigoted critics, who compared this *supposed* condition of the stars to the pairs of soles on a fishmonger's stall. Now the most accurate observations have shown that these stars move round each other, and thus from year to year they alter their relative position; hence the name of *fixed* star is a misnomer.

The third star from the tail of the Great Bear is a double star; the two stars appearing to move round, or the one to revolve round the other, in a period of about fifty-eight years. Castor, one of the twins, consists of two stars; a period of about two hundred and fifty years being assigned to the revolution of one of these. Rigel, the Pole-star, ε Bootis, γ Virginis, α Hercules, and many other remarkable stars, are double; in fact, nearly six thousand double stars are already known.

DOUBLE STARS (Telescopic)



Vincent Brooks lith

1 β Cygni. | 3 α Geminorum. | 5 μ Sagittarii. | 7. 51 Libræ.
2 ε Bootis. | 4 η Cassiopeiæ. | 6 Polaris. | 8 ε Liræ.

Arcturus is a star which the reader will now be able to find. About ten degrees to the north-east of Arcturus, or, more definitely speaking, about ten degrees up a line drawn from Arcturus towards Vega, we find a star called *Mirach*, which is double, the contrast of colour between the two stars being very beautiful. In addition to double, there are some groups of triple and quadruple stars; the star appearing single when seen with the naked eye, but triple or quadruple when examined with a large telescope.

By examining the records of ancient astronomers it has been found that there are variations in the brightness of the stars; some appear to be getting dim, whilst others are more brilliant than formerly. Some stars have disappeared entirely, as was the case with the seventh star of the Pleiades, which it was said vanished when Troy was taken. In modern times it is found that several stars vary in brightness during certain periods, some occupying from five to ten days to pass through

their changes, whilst others occupy three or four hundred days in returning to their same condition. In some instances a star of large size has appeared merely for a short time, and has then suddenly been lost sight of.

The principal object to be observed in connection with the stars, if provided with a telescope, is the relative position of the double stars, and the beautiful diversity of colour existing between them. When the two stars become visible in the telescope, it can then be seen that they are usually of different colours. Some of these contrasts are very lovely: a rosy tinge is possessed by one star, its companion perhaps a beautiful green; this is the case with a star called 24 Comæ Berenicis.

The prevailing colour of the attendant stars is blue or greenish blue. Sometimes they are of the same colour as the principal star, but this is not usual.

It is found that certain stars which formerly shone with a white or red light, now appear of a different colour, and thus there appears to be

a change of some kind occurring in every portion of the universe.

If we examine the earth beneath our feet, we find that from the very earliest ages to the present time there has been one continued change, or onward movement. We may perceive cropping out in various localities an accumulation of hard rocks which formed the surface soil in ages long since past: these rocks were not capable of affording nourishment to plants or trees until they had been submitted to certain actions during long periods of time.

Again, we find that in a subsequent epoch plants of various kinds flourished abundantly, whilst the earth was still untenanted by a numerous class of the animal creation: then we recognize a period when animals of vast size roamed over our now fair earth, and reigned monarchs of the plain, forest, and river; man being still an unknown creature in this planet. History teaches us that there was afterwards a time when vast hordes of men peopled the world, whose minds were comparatively con-

tracted, and whose aims were limited. If a modern *savant* with his knowledge of telescopes, steam, electricity, photography, and other scientific facts, had existed some seven or eight hundred years ago, he would probably have been treated as a deity by those who were then capable of perceiving the utility of the subjects with which he was acquainted. Thus we find amongst men that PROGRESS has been one of the most prominent characteristics. Hence from the period of hard unfertile rock to that of the present day, there has been one onward movement; and even now we are living in an epoch which daily presents some change by which the crude or erroneous opinions of the past become trimmed so as to more nearly approach truth, and hence to be more in harmony with that Divine wisdom which has created all the vast celestial machinery as well as the minds by which his works can be comprehended. When we find that there are stars which disappeared, changed their colour, appeared or are variable, we are induced to reflect

upon the probable cause or purpose of these changes, and to form conjectures as to the various appearances which our own earth might have presented at different times. It is at least probable that when a star changes its apparent colour there is some change of condition in that star. Perhaps its atmosphere may have become affected by the approach of some other celestial body; the electrical or magnetic condition of the star may have varied, or the body may be passing through various epochs and in rapid succession, much in the same manner that our own planet passed through changes which occupied ages of time before they were completed. To know that creation is not stereotyped in one form is a most interesting fact; and we become aware of this whether we observe the distant suns and worlds, or examine the earth beneath our feet.

Nebulæ.

An attentive examination of the sky during a clear night will enable an individual, even with the unaided eye, to perceive several whitish-looking foggy patches of light, which appear somewhat like the mist which at times surrounds a bright star. If a telescope of even the smallest power be turned towards these patches, it will be found that they consist merely of an accumulation of small stars grouped very closely together.

When the telescope is directed to various parts of the heavens, there will be seen many of these misty patches, which then appear with the aid of the telescope very similar to the groups of small stars if examined with the unaided eye. These groups or patches of misty matter are called Nebulæ.

With the aid of the most powerful telescopes some of the so-called Nebulæ have been *resolved* as it is termed; that is, they have been found to consist merely of groups of stars in close proximity to each other. There are still,

NEBULÆ.

Vincent Brooks lith.

1. In Hercules. 3. In Cassiopeia. 5. Dumb Bell *in Vulpecula*.
2. „ Antinous. 4. „ Andromeda. 6. In Lyra.

however, several nebulæ which no telescopes have resolved, and which appear misty even when examined with high magnifying powers.

An observer who may be provided with any small telescope will find that he is able to resolve some of these patches of light. Aldebaran is a star easily found from the description already given; close to Aldebaran there is a group of stars which to the unaided eye presents this misty light appearance. There are also two patches close to Cassiopeia.

CHAPTER XI.

COMETS.

The most mysterious bodies in the heavens are certainly comets. The planets we can readily imagine to be, and there appears every probability that they are, the residence of created beings of some kind. The sun and the fixed stars appear to be the centres of systems to which they contribute light and heat. When, however, we examine the form and condition of these singular wandering bodies which are called comets, it is difficult to conceive that they are as yet fitted for the residence of any material beings; and it would be no less in opposition with the analogy of nature, to assert that they have not their use in the economy of the universe.

In ancient times, it was the custom to state and believe, that comets produced diseases and losses to princes, as well as to peasants, and they

COMETS.

Vincent Brooks lith

1. Encke's.
2. Comet of 1858.
3. 4. 5. Halley's.
6. Gambart's, *in two parts.*

were thus considered messengers of evil. In more modern times these visitors were supposed to be the vehicles in which the spirits of the departed were conveyed to some special *locality* assumed to be that of Paradise.

Some of the ancient philosophers believed comets to be a sort of meteor which existed in the atmosphere of the earth; whilst others ventured very daring and, for their time, unorthodox opinions, and asserted that comets were probably *nearly* as high up as the moon.

Comets may be divided into two classes, viz., those whose course is known and whose reappearance can therefore be foretold, and those whose course is unknown, and whose visits are therefore uncertain.

There are some comets whose course is known, and whose return to any point in the heavens can be predicted; but these are insignificant in appearance when compared to some of those brilliant visitors, which gleam for a period in the heavens, and then dash away into endless space.

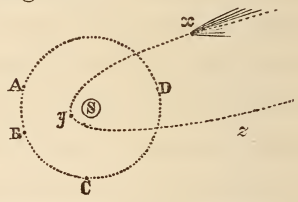
Comets first become visible to us in a variety of ways. The mere searcher of the heavens, who night after night directs his telescope to various parts of the sky, may at length perceive a small speck of light which differs slightly in appearance from a star. An examination of this body during a few evenings, may show that its position changes very rapidly, and that it is moving amongst the various fixed stars. The first fact resulting from this discovery would be, that the speck of light was either a planet or a comet, and a very few evenings would enable an observer to decide which of these bodies he had discovered. If the comet were approaching the sun, it would probably become more and more distinct each night, and would soon become visible to the unaided eye. When thus distinct it usually appears like a small star, with a slight ray of light shooting out from the bright portion. The mere casual observer might not at first perceive any difference between this comet and a star; but a little attention would soon show the difference between

the two. If the comet were a large one, and passed near the earth, it would become not only a remarkable, but a splendid object in the heavens. There can then be distinctly seen a bright head, or nucleus, as it is termed, and from this there are diverging rays of light or vapour which extend to a considerable distance behind the head of the comet. This brilliant body moves on with great rapidity, and is at length lost sight of in consequence of its approach to the sun. The above description of the changes which occur with a comet holds true when a comet is seen as it approaches the sun.

With the aid of a diagram we will now show the usual course of a comet, and also endeavour to explain why they are sometimes seen only as they are travelling away from the sun, and why some also suddenly appear, and of a very large size.

The earth travels round the sun, and at a nearly uniform distance, this being the usual course of a planet. A comet passes round the

sun, but not *completely* round it, then travels far away beyond the range of our sight, we know not where. The respective courses of a planet and comet may be understood from the following diagram:



The circle A B C D represents the earth's orbit round S the sun; *x y z* represents a portion of a comet's orbit, which may extend to one hundred times the distance from the sun that the earth's does. If the earth were at A when the comet was at *x*, the comet would scarcely be seen, as it would be so close to the sun that it would set immediately after it, and thus on account of the light would not be visible. If then the comet moved from *x* to *y* and *z*, it would reach the point *y* perhaps when the earth was at B, and would thus be invisible in consequence of the sunlight. Then as the comet

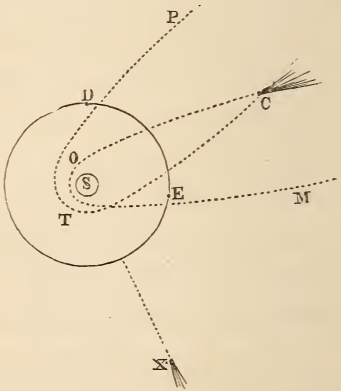
moved to *z*, the earth would have travelled to C, and the comet would now be visible for a short time just before sunrise. It would be travelling from the sun, and at a great distance, therefore not a very noticeable object in the heavens.

If, however, the earth had happened to be at the point D in its orbit when the same comet was at *x*, then it would have been distinctly visible, and would have been in the south about midnight. When the earth moved on towards A, the comet would have passed round towards *y*, and would thus have disappeared.

Whether we see a comet distinctly and for a long period, as it approaches or moves from the sun, depends therefore entirely upon the relative positions of the earth, the sun, and the comet.

Any person, however, although not scientific, or acquainted with mathematics or astronomy, can draw a circle, can place the sun in the centre of this circle, and can make a mark to indicate the position of the earth; then if it be

announced that a comet is visible in any part of the heavens at a certain hour, and is moving toward, or away from the sun, he can sketch the most probable course of the comet, and can then see where it is likely to move to. For example, suppose a comet were observed in the month of September, and was visible at midnight in the south-east—we can draw a circle



D E, which represents the earth's orbit, S being the sun, E the position of the earth in September, which moves round towards D. At midnight in September the south would be in

the opposite direction to that of the sun; therefore the south-east at midnight would be in the direction E C. A very few observations would show whether the comet was moving towards or away from the sun, for if it increased in apparent size or brightness, we should know at once that it was approaching the sun. This comet if approaching the sun would move either as shown by the curved line C O M or by the line C T P. Whichever course it followed, it would come very near to the earth, and would therefore be a much more remarkable object in the heavens than when first observed. If the comet moved in the course indicated by C T P, we should probably also see it upon its return *from* the sun, for the earth would have moved round towards D, whilst the comet had travelled from C to T and round towards P. If the comet pursued the course shown by the line C O M, we should see it clearly only when it was moving towards the sun, for as it moved away it would be between S and M, and therefore

behind the sun, because the earth would be near the point D.

If in September a comet were observed at midnight in the *south-west*, this comet would be in the direction shown by X. Then as the earth moved on from E towards D, and the comet from X towards S, it would soon be lost to view in consequence of its approach to the sun.

Sometimes a comet will approach the sun from what we should call a *high* point in the heavens: when this is the case it may be clearly visible in the *north* at midnight, the sun being then in the north, but below, whilst the comet is above, the horizon. Some very fine comets may be seen in this position, the last brilliant comet that visited us having been during a considerable time in the north about midnight, whilst retreating from the sun. Any novice can, however, roughly calculate whether a comet is likely to be a very remarkable object in the heavens, by drawing a circle, and placing on this a mark to indicate the earth's position,

then sketch the position of the comet and the two courses which it may pursue.

Referring to the preceding sketch, the comet would be said to be moving *direct* if its course were C O M, because this is the way in which the planets move round the sun. If its course were C T P, it would be said to have a *retrograde* motion, because this is the opposite course to that which the planets pursue. When it is announced, therefore, that a comet is visible in the heavens, and that it is moving towards the sun with a *direct* motion, a little sketch will soon enable us to judge whether the comet is likely to approach the earth, or to be visible for any length of time.

We may perceive by an examination of the sketch that it would be quite possible for a comet to approach the sun, move round it, and travel away without being seen from the earth. Such a position as D, for instance, would prevent us from seeing the comet X, which might pass round the sun from T to O, and thus remain invisible during its whole course.

There are various kinds of comets, or they may visit us in different stages of development; for there are—

Comets without a nucleus.

Comets without a tail.

Comets, the nucleus of which is quite transparent.

Comets, the nucleus of which is either opaque or solid.

It is believed to be an invariable rule that the tails of comets always point *away* from the sun; so that, whichever way a comet may be moving, it does not draw its tail after it, but the tail appears driven away from the solid or more dense portion by the action of the sun. Hence "*tail*" is a misnomer; for a tail never *precedes* any body, but ought to follow; whereas the tail of a comet retreats from the sun before its head, and thus imitates a courtier retreating from the presence of majesty.

Occasionally variations from an apparent rule are observable: thus, a comet which was seen in 1823 had two tails, one of which was as

usual turned away from the sun; but the other, with a total disregard of all cometary etiquette, was turned directly towards the great luminary of our system.

Many cases are recorded where a comet has possessed a tail divided into several distinct branches, some having as it were five or six tails.

The size and brilliancy of the nucleus of a comet are no guides to the dimensions of the tail, some large tails being attendant upon a small nucleus, and *vice versâ*.

There are three comets in particular which belong exclusively to our solar system, and which return at regular known intervals. These present peculiarities which are very interesting, and which have served for a fertile field of speculation. The first *periodic* comet, as these bodies are called, is named after Dr. Halley, the celebrated astronomer. The other two are named after the two astronomers who first calculated their orbits, viz., Encke and Biela. Encke's comet travels round the sun within the orbit of

Mercury on one side, and then journeys nearly as far as Jupiter on the other. This comet has revealed two very singular facts; first, that when near the sun, its diameter is very much smaller than when at a distance: thus the sun appears to condense the particles of which this comet is composed. Secondly, the return of the comet to a certain point does not occur uniformly, but there is a gradual decrease in the period. Thus, it might occupy 1069 days and 12 hours to move completely round its orbit when we observed one revolution, but merely 1069 days and 8 hours during the next; 1069 days and 4 hours for the third, and so on with a gradually decreasing rate. These two facts have of course caused considerable speculation to be expended upon the results which might possibly happen to the various members of the system.

We will now refer to the speculations and conjectures which have been offered in connection with comets.

Among the earlier conjectures about comets were those which we have already mentioned,

viz., that they come as messengers of evil, or were the vehicles for conveying good spirits to other parts of the universe. A messenger with a tail about thirty millions of miles in length would be rather an extravagant courier to be employed by the divine Architect of nature, whose works so decidedly testify that economy is one principle of the universal system.

Another supposition as to the use of comets was, that they revolved a few times around our central luminary and then dropped into him, and thus "kept the kettle boiling;" or, in other words, supplied the losses which, it was assumed, the sun suffered by giving out heat and light. In an age when a blazing fire, or some sort of fire, was supposed to be the only cause of heat, such a speculation as the above did not seem absurd. Now, however, those who reason amongst us would not be disposed to grant either that the sun is on fire, or that it requires fuel to keep it going. Such a theory also might explain the *finale* of a comet, but it would leave its origin in obscurity.

Will a comet ever run away with the earth, or run against it? or will the tail of a comet ever surround the earth? are questions which have been gravely asked, and seriously answered. Are comets habitable? do they produce diseases or fogs? and will they disturb the earth's motion? are considered fair subjects for inquiry.

The speculations of M. Laplace upon the supposed effects which might happen, assuming that a comet was solid, and that it could run foul of the earth, produced great consternation in Paris, where good situations in Paradise were sold to the credulous at a fair market price, when a large comet became visible in the heavens.

A collision is much more in character with the proceedings of a couple of intoxicated cabmen, than with those of the works of nature in which order, harmony, and arrangement are everywhere visible.

In the year 1770 there was a comet which passed twice through the system of Jupiter, yet

it produced not the slightest effect upon the movements of Jupiter or his satellites. When a collision between a planet and a comet is spoken of, it is assumed that the comet is hurled blindly at the sun, whilst the planet still rushes around its orbit, and that therefore it is merely a matter of luck or chance whether the two run foul of each other. Are we warranted in assuming that anything in nature is left to *chance?* is it not more probable that the very law which brings comets towards the sun, may serve to keep them at such a distance from the planets that no disasters may happen? A planet, like one pole of a magnet, may have a repelling as well as an attracting power; and though at certain distances a comet might be attracted to a planet, still, if the distance decreased, this attraction might cease.

It is possible, nay, almost certain, that comets have an use: it does not appear that they are required to supply the sun with fuel; for they pass around him, and travel away into unknown regions. May they not be the agents for gather-

ing up all those gases or used vapours which may be thrown off by the sun and the various planets—celestial dustmen, in fact; who come merely when the condition is such as to require them, and which are attracted by a sort of self-adjusting law when the system requires their presence?

From our sun they may travel to another luminary, and may thus serve to maintain a balance between various portions of the universe; extracting from one group that which may be dispensed with, and imparting this to another where it may be required. Thus when the comet that we have spoken of as visiting the Jovian system passed twice close to the planet Jupiter, it was probably playing the part of scavenger, and relieving that system of elements which were no longer required.

It is possible also that a comet, when once called into existence, may have a definite destination, which may depend upon the affinity of the particles of which it is composed towards various portions of the universe. For example,

a comet may perhaps move around two suns for a long period, until it reaches a certain state, when it might become merely the attendant of one of these. The comet of Encke, for example, belongs exclusively to our system; and we see that this comet has merely a less dense or compact form than a planet, and a more elliptical orbit. This orbit is decreasing in ellipticity, whilst the comet is gradually assuming more and more the course of a planet. Let these changes continue during many ages, and we shall at length have to call this comet a planet, as it will then differ in no essential particulars from a planet with a very elliptical orbit.

The fact of the comet of Encke having been observed to be gradually contracting its journey of revolution around the sun, has led to the conjecture that what we term *space*—that is, the intervals between the sun and the respective planets, &c. — is filled with some subtle fluid which opposes the motion of bodies, this fluid being termed a *resisting medium*. Hence it has

been supposed that, in consequence of this resisting medium, not only all the comets, but all the planets, will eventually tumble into the sun, the moons upon their primaries, and the whole of the bodies in the universe will be bumping and knocking against each other.

There are one or two trifling preliminaries which have to be assumed before this disastrous state of confusion could be reached, and these we will briefly consider.

The belief of the existence of a resisting medium arises from the following mixture of facts and suppositions.

It is a law of motion that if a material body be given an impetus in any direction, a movement will take place, and continue for ever unless some opposition be offered. So also, a comet, *if flung* towards the sun, would continue to move at the same rate and time, provided there were no resisting medium to oppose it. "The comet does not move uniformly; therefore there is a resisting medium." This reasoning might have passed muster in a bygone

age, when cause and effect were but little studied, when hypothesis rested upon theory, and theory upon guesses, the whole being surrounded by a maze of figures to protect the assumption from the criticism of the inquirer: but some further probabilities must now be examined before we grant any such theory as that all the comets and planets are going to tumble into the sun.

In the first place, are we *quite certain* that comets have really been flung or launched in their orbits by some mechanical agency. If we are not certain of this, the theory of the resisting medium rests upon a guess; whereas a theory ought to be based upon well-established facts. Again, let us grant the singular assumption that this gaseous body was launched or hurled towards the sun from some out-of-the-way locality beyond the orbit of our earth, and we are not driven to the necessity of granting that it will fall into the sun, in consequence of a resisting medium. We know that as the comet approaches the sun, its diameter de-

creases; are we then certain that the sun may not, each time the comet approaches it, cause the comet to become more and more solid and less gaseous? In fact, to become more planetary and less cometary in its constitution? Such a change would cause the comet to decrease its period of revolution, even according to the laws of mechanics as interpreted by us; and the body, by these transmutations, might at length take its place in the system, as an inter-Mercurial planet, with a density even greater than that of Mercury, and with an orbit not less elliptical.

It is always an advantage to have a choice of theories; and we are impressed with the idea that progression in Nature's vast works is so much more agreeable to reflect upon than collision, confusion, and destruction, that we trust the reader will pardon the somewhat lengthy conjectures offered upon the probable use and destination of cometary bodies.

Vincent Brooks, lith

Aurora Streamers.

CHAPTER XII.

At uncertain periods and intervals there is visible near the northern portion of the heavens a very beautiful phenomenon, called the "Aurora Borealis." The aurora presents during a very short time various changes, which, for the sake of distinction, have been designated by different names.

The first indication of the advent of an aurora is a light appearance in the northern sky, somewhat similar to the dawn of day. This light is usually seen about one or two hours after sunset, and has been called the *aurora twilight*. This "twilight" varies in intensity, and serves as an indication of the coming aurora, which should be looked for during the evening.

As the evening advances *arches* of light, in

form somewhat like a rainbow, may be seen to stretch from the north-east round to the north-west; these arches are usually pale yellow or whitish.

From these arches, or from some dark smoky-looking clouds which usually rest near the northern horizon, several *streamers* will be seen to shoot up from the north towards the heavens above us. These streamers are bright, and commonly pale blue or pink, and they flash and rush upwards with great rapidity.

A circle of either pure white or of various brilliant colours, with streamers shooting out from it, is frequently observed during the aurora. This circle is usually around the point in the heavens towards which the pole of a balanced magnetic needle would point, and it is called the *corona*.

In addition to the streamers there are sometimes undulations or *waves* of light, which flow upward towards the corona or along the line of an arch.

In addition to the above there are milky sort

of clouds, which have a self-luminous appearance, and which prognosticate the intensity of the aurora.

In England the aurora is not a very common phenomenon; but in North America and in northern regions it is frequently visible. Still, if an individual is acquainted with the preliminary indications of the coming aurora, he may frequently observe this beautiful and mystical effect.

A very beautiful aurora was visible on the evening of the 9th March, 1861: a description of this may serve to explain the general appearances of the phenomenon.

At a very short distance above the northern horizon, and at about half-past 8 P.M., there gradually appeared a sort of green-tinted twilight, as though the sun were going to rise. A few dark clouds then gathered in the centre of this light, which soon varied in intensity, some faint pale-bluish streamers then shot upwards from the N.N.E. and from the N.N.W. points of the horizon. These streamers reached nearly

overhead, but as they ascended they changed their hue, and became of a warm rosy colour. They extended east and west, lost the streamer form, and illuminated the heavens just as though some large fire were casting reflected light into the sky. These appearances came in flashes, and there were intervals of several minutes when no streamers were visible. The aurora continued during nearly two hours.

From observations which have been carried on during upwards of a century, it is found that the greatest number of auroræ occur in the month of October, and the fewest in June. The ratio being as follows:—October, March, November, September, December, February, April, January, August, May, July, June. This ratio it is believed is liable to variation, which some inquirers suppose to be periodical.

It has been found that at certain periods, both during the day and night, there are currents of a subtle element rushing over the earth's surface. These are usually called magnetic or electrical currents, because they cause

a magnetic needle to slightly vary, and also produce singular effects upon the needles of the common telegraph. When an aurora occurs these disturbances are considerably increased, and it is sometimes almost impossible to send a telegraphic message when an aurora is in force. The aurora is seen best in the higher regions of the earth, and better in the western continent than in the eastern. From these facts we are at once led to conclude that the aurora is probably a magnetic phenomenon. We are not yet aware how the proper balance of electricity or magnetism is maintained upon and in our earth, nor are we yet made acquainted with the exact relation which exists between these two forces. We know that electrical storms occur at certain intervals, but we are not fully aware of the cause of these, which after all must be merely the effects of other effects. It may be then that, when there is a superabundance of magnetism in the earth, this surplus is discharged from *both* magnetic poles: the rapid passage of the magnetic element

through the atmosphere producing light. Hence it is probable, should this supposition be true, that at the same time an aurora would be visible both in the northern and southern regions. It is possible that this may be the case for many other reasons, which would, however, be beyond the course of this little work to adduce.

A very little observation directed towards the northern horizon soon after sunset, especially in February, March, September, and October, will be rewarded by a view of the brilliant phenomenon called the *Aurora Borealis*.

METEORS AND AËROLITES.

At various times of the year, but particularly in the month of August, a brilliant star-like object may be seen, which shoots along the sky for a short distance, and either disappears as though it "went out," or bursts with a loud report. These objects are commonly called METEORS, AËROLITES, or SHOOTING STARS. The fall of these singular bodies afforded one of the many examples

of the danger that surrounds those men of science who believe that they have solved all the laws of nature. "The Academy of Sciences," says M. Arago, "declared in 1769 that the stone picked up at the instant of its fall at Lucè, by several persons who continued to perceive it until it reached the earth's surface, had not fallen from the heavens," and the *savants* of Europe affirmed "that the fall of stones from the atmosphere was impossible." As M. Arago justly remarks, "It is certain that physicists who refuse to admit any facts except those which they perceive to admit of explanation, do more injury to the progress of science than men who are liable to the reproach of being too credulous."

It has been found that in nearly all the masses which have been ascertained to have fallen from the atmosphere, there is a preponderance of nickel. Some of these masses are hard, whilst others are spongy.

We have the record of several accidents which have been caused by aërolites; and when

we consider the weight of some of these bodies, it is not remarkable that accidents should occur. In 1674, a ball weighing nine pounds killed two men on board a Dutch East Indian vessel. An aërolite fell in New Granada in 1810, and weighed upwards of sixteen hundred pounds.

Globes of fire which suddenly appear and then vanish are usually termed BOLIDES. Sometimes bolides give out a very bright light, or leave behind them a train of fire; occasionally they burst into several pieces, which form those falling bodies of which we have spoken.

Aërolites have afforded a fine field for conjecture, since men of science admitted that they were possible. It has been supposed that a ring of these bodies revolves about and surrounds the sun, and that the earth passes through this ring in August, when, consequently, the greatest number become visible. Other speculators imagine that they are fired out of the volcanoes in the moon. But, as we do not yet know that the lunar volcanoes are active, and we have to

assume a velocity of projection of upwards of eight thousand feet per second, this conjecture is rather baseless. It may be possible that the elements of which asteroids are formed exists in space, and that these become solidified by agencies occasionally at work, and which may be induced by the earth's electrical or magnetic state, just as water may be formed from its elements by the electric spark.

THE END.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET.

Bindery
R. MARCHBANKS
INDIANA

LIBRARY OF CONGRESS
0 003 630 325 6